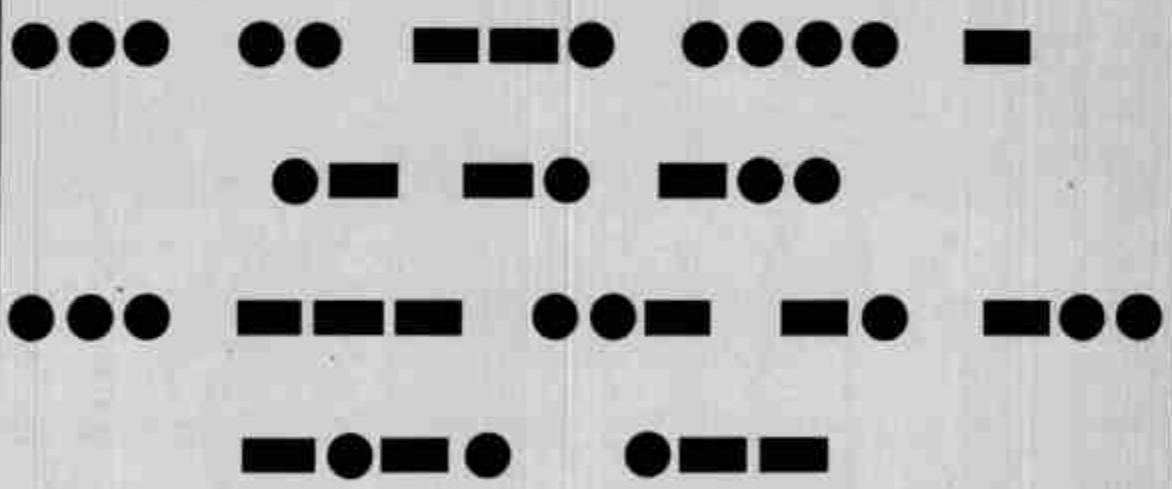
JANUARY 1988 / $2.50

ham radio magazine

W6NRW



Sight and Sound CW

hr
focus
on
communications
technology

ham radio magazine

JANUARY 1988

volume 21, number 1

T. H. Tenney, Jr., W1NLB
publisher

Rich Rosen, K2RR
editor-in-chief
and associate publisher

Terry Northup
assistant editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
editorial production

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Rally Dennis, KA1JWF
director of advertising sales

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Farm Color
cover

ham radio magazine is published monthly by Communications Technology, Inc.
Greenville, New Hampshire 03048-0498
Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail),
one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 111

Microfilm copies are available from
University Microfilms, International
Ann Arbor, Michigan 48106
Order publication number 3076

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals,
919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1987 by Communications Technology, Inc.
Title registered at U.S. Patent Office

Second-class postage paid
at Greenville, New Hampshire 03048-0498
and at additional mailing offices
ISSN 0148-5989

Send change of address to *ham radio*
Greenville, New Hampshire 03048-0498

contents

10 sight and sound CW
Don E. Hildreth, W6NRW

17 a battery-backed master power system
Eric L. Smitt, K9ES

25 new uses for old tuners
Hugh Wells, W6WTU

35 morse code teaching tools for the C-64 and 128
Dennis L. Green, KB8CS

38 build a QSO "beeper"
Richard L. Erhardt, KF6CU

52 radio addition: case history of an enthusiast
Robert J. Zarvel, Jr., W7SX

54 the technology of commercial television part 2: hardware
Eric Nichols, KL7AJ

69 ode to older oscilloscopes
W. Clem Small, KR6A

75 practically speaking: drift and shift
Joe Carr, K4IPV

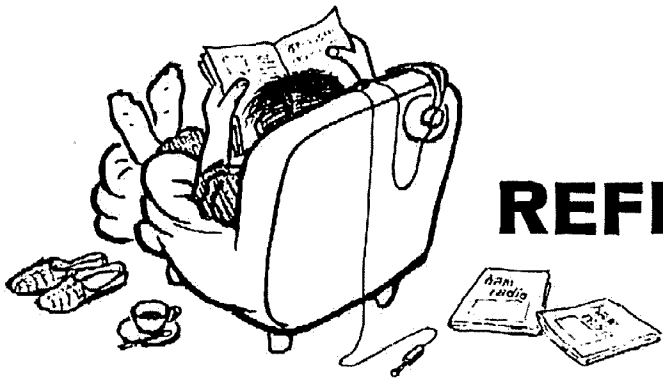
83 the weekender: power speaker enhances mobile operation
Peter Bertini, K1ZJH

89 ham radio techniques: the year was 1923...
Bill Orr, W6SAI

100 Elmer's notebook: power measurements
Tom McMullen, W1SL

Joe Reisert's column returns next month.

114 advertisers index and reader service
9 comments
96 DX forecaster
112 flea market
87 grid locator
110 ham mart
107 new products
4 reflections



REFLECTIONS



Hello Terry, Good Luck Dorothy

Meet Terry Northup, our latest addition to the Ham Radio magazine staff. She has handily started taking over the responsibilities once enjoyed by Dorothy Rosa and will be working with our authors to communicate the quality technical information that you expect from us. If one is allowed to judge by first impressions Terry brings to HR, besides her obviously finely-tuned editorial skills, a vitality and spirit that is synonomous with what we perceive is needed in Amateur Radio in general.

Dorothy, prior to leaving for her new job as Senior Editor of 80 MICRO (International Data Group's monthly magazine for users of Tandy's MS-DOS) shared with us her feelings about Terry and about her own 5 years on the staff at HR.

"Terry, a skilled journalist and former publicist for the American Trucking Association brings relevant experience and strong writing, editorial and 'people' skills to a position that's as personally rewarding as it is professionally demanding. She also brings a resilient sense of humor and what a former employer described as a 'fine sense of the ridiculous'. That's good because she'll need both qualities in considerable quantity."

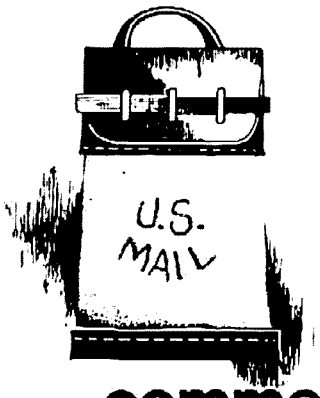
If you consider that magazine, newspaper or any periodical production can be likened to a smooth running machine, a treadmill really, that relies on all the participants contributions to maintain demanding schedules then you get to appreciate everyone's efforts. Dorothy recognized this when she tried to sum up her 5 years at the magazine.

"It's difficult to say goodbye to my colleagues at ham radio- not just to those whose names appear on the masthead, but to those whose names you never see: Beth McCormack, editorial department secretary: Teresa Leger, bookstore manager; and Phil Alix, chief of shipping, inventory and logistics. For ability, patience, and tireless goodwill, these folks are tops."

Dorothy, never really at a loss for words had one last message for the authors and columnists: "Goodbye, guys...73,88—and get those proofs back on time, darn it.!"

The voice will be different and the methods as well but the message will still be the same ... Ham Radio magazine—how may we help? Get in touch with Terry and see what we've already discovered and I'm sure you'll enjoy working with her.

Rich Rosen, K2RR
Editor-in-Chief



comments

the INUS system

Dear HR:

The INUS system can provide an answer for the "possessed" described in K2RR's editorial (October 1987), which I appreciated so much.

According to INUS, all actions and possessions are either Indispensable, Necessary, Useful, or Superfluous (INUS). The actions and possessions of DX-minded Hams can be categorized as follows:

Indispensable: an antenna (tubing or wire), a proper transmission line, a 12-VDC mobile rig and a battery (or whatever, as long as it's able to receive and transmit), a key, a headset, a log, and a clock — plus a lot of determination and careful listening.

Necessary: a steerable antenna with more bands, a mike, an SWR meter, an antenna tuner matched to a linear amplifier for low-band DXing, a place in the house for the station, an operating manual, a book on propagation, a subscription to a DX bulletin — as well as patience, spare time, and a world atlas.

Useful: a keyer, a grid-dip meter or antenna bridge, a 2-meter HT. Maybe get a new gray or black box, see what's inside and how it compares with my brave 15-year-old rig?

Superfluous: all things not classified above, including pieces and parts for homebrew projects never completed and other parts that were to be used for all those *Someday I'll build a . . .*'s. Maybe awards can be put here! (Heresy perhaps, but really, it's not the paper that makes the fine DXer, the good friend, the helpful Elmer . . .)

Because junkboxes tend to grow out of control, it's best to go through them and keep only those items you really need. But selecting the useful goodies isn't so easy; there are many reasons we keep things. In such as case, apply the "time test": any item not used during the first year after purchase, should be assigned second-class status. If it hasn't been used after a second year passes, it's best to sell it, trade it, or give it away. Better yet, make a collection and offer the whole thing to a radio museum. When the SK hour rings, I'll bring nothing along . . . .

A station covering more than a normal sized desk — one layer high — is in danger of elephantitis. And the ham who chooses to get involved in more than one mode soon discovers that too much rig = too much money and too little time dedicated to each individual mode; results are poor.

People eat for hunger or appetite. If they eat for hunger only, they are able to maintain a good physical and mental form, and actively enjoy life. In the second case, the choice of diet is impulsive, not balanced. Fat accumulates, cholesterol levels go up, and sedentary diseases appear. (Being an M.D., I see that every day.) The same is true for ham stations . . . .

Dr. Michel Christ, XE1MD
Mixcoac, Mexico 03900

short circuits

dc-dc converters

In W3CZ's October, 1987 article, "Pulse Width Modulated dc-to-dc Converters," the artwork shown in **fig. 1** should be moved to **fig. 3**. The artwork shown in **fig. 3** should be moved to **fig. 1**. The captions should remain as shown.

In **fig. 5A**, the IC block diagram is of the SG3524, not the UG1524 — in fact, the text states this. In addition, the LH1605K is not available from Digi-Key as stated; the LM3524 is.

Are you radioACTIVE?



Dean LeMon, KR0V sure is! Dean got active in Amateur Radio when he was 16 years old and earned his Extra Class license in less than four years! "It's a facinating hobby and a great way to meet all kinds of new people from all over the world."

Dean has cerebral palsy and got started in Amateur Radio with help from the Courage HANDI-HAM System. The HANDI-HAM System is an international organization of able-bodied and disabled hams who help people with physical disabilities expand their world through Amateur Radio. The System matches students with one to one helpers, provides instruction material and support, and loans radio equipment.

Isn't it time you got radioACTIVE with the Courage HANDI-HAM System?

Call or write the Courage HANDI-HAM System W0ZSW at Courage Center, 3915 Golden Valley Road, Golden Valley, Minnesota 55422, phone (612) 588-0811.

Are you radioACTIVE?

sight-and-sound CW

Visual and aural correlation enhances capture, protects ears

In my general search mode in our CW bands, I usually prefer to listen with a bandwidth of 500 Hz or more. This relatively wide bandwidth makes the mechanics of tuning easy, giving my "ear-brain" filter free rein. Only when the going gets rough in terms of noise or QRM do I switch in my very narrow, steep-skirted filter. In the past when I did this, I often lost and had to retune the very signal I was trying to isolate.

Fortunately, adding this small electronic device to your receiver can do wonders. By taking advantage of your brain's ability to correlate visual and sonic inputs, it helps you make the transition from wide to narrow bandwidths quickly, easily, and with precision.

hearing and seeing CW

Our ear-brain filter capability enables us to focus our attention on a bandwidth as narrow as 50 to 100 Hz (it varies with the individual), anywhere within the normal audio range. For example, if you're one of the lucky ones who can focus to a 50-Hz bandwidth, and your receiver has a 3-kHz noise bandwidth, you can generally hear a CW signal nearly 18 dB below the noise. This "focused" bandwidth is inferred from the power of a single tone that you're able to perceive in relation to, and in the presence of, a known power contained in an audio bandwidth of white noise. (It doesn't take into account the difference in antenna noise and copy error rates, however.)

In a practical sense, this means that even if no other signals are present and you increase the gain of your receiver to bring a very weak signal to a 70-dB sound pressure level,* you'll present your hearing mechanism with a sound pressure of nearly 90 dB from noise alone. If there are other signals within the 3-kHz bandwidth, the sound pressure total may exceed 90 dB. Permanent hearing damage begins when sound pressures reach approximately 90 dB for extended periods, and the amount of exposure time necessary for damage to occur is said to decrease as the sound pressure level increases. These factors present a compelling argument for the use of a narrowband filter, even if you can copy that weak DX signal in the presence of noise and QRM and don't think you need one.

Admittedly, switching to a narrow filter can be awkward — and the better the filter, the worse it gets, because although our ear-brain filter is good at detecting incremental frequency changes, it's not nearly as adept at recalling or recognizing an absolute frequency. As a result, if you're listening to a signal using a relatively wide bandwidth and you shift to the narrow, steep-skirted filter, chances are you'll lose the signal and have to retune to find it. The odds are about 50 percent that you'll not only tune in the wrong direction but also have to retune very slowly, consuming precious time and feeling your frustration mount.

To overcome this problem, you can put the brain's ability to correlate sight with sound to work. Even though visual copy of CW is limited in speed, it can help compensate for the ear's weakness in absolute frequency recognition. To provide this capability, all you have to do is add an LED, with associated circuitry, that's driven by the output of a narrow filter. The block diagram in **fig. 1** shows a typical arrangement.

Using the blocks shown, the narrow filter, LED driver, and power amplifier are constantly ON. Input to the power amplifier is selected either from your receiver's output or from the filter. The inclusion of substantial voltage gain in the power amplifier ensures the ability to listen to a filtered weak signal at a moderate-to-low gain level from your receiver. This is desirable because the presence of strong signals outside the filter bandwidth, but inside your receiver's bandwidth,

* 0 dB is the threshold level of human hearing. 70 dB is the approximate sound pressure level of a one-on one conversation.

By Don E. Hildreth, W6NRW, 936 Azalea Drive, Sunnyvale, California 94086

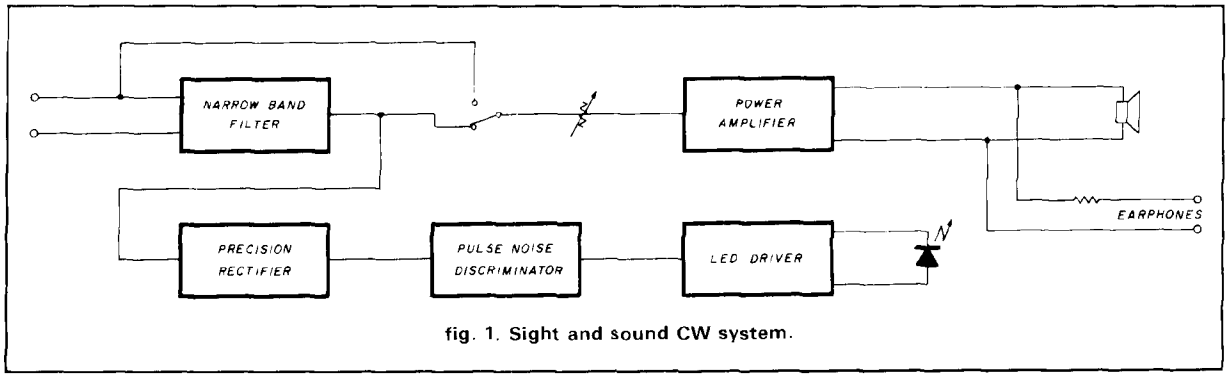


fig. 1. Sight and sound CW system.

could saturate some receiver stage if the receiver's gain is high.

system details and function

Figure 2 shows the circuit details of an eighth-order synchronous filter with a design bandwidth of approximately 40 Hz, a precision rectifier with a voltage gain of 10, a pulsewidth noise discriminator (PND), an LED driver transistor, and power amplifier.

In operation, a signal tuned to the filter's center frequency is fed to the input of the precision rectifier. The output from the rectifier is conditioned by an emitter-driven buffer to drive an emitter-coupled pair of transistors that serve as a PND. With the circuit values shown, the LED will respond to signal input amplitude levels from a receiver down to a nominal 0.1 volts RMS. The PND acts to ignore any signal until it has existed for a minimum length of time as determined by the installed value of R_t. As shown, this circuit doesn't recognize any signal voltage until it has existed for about 20 milliseconds. In addition, the circuit resets in less than one millisecond after an accepted signal stops. In this way, impulse noise, which usually lasts for less than 20 milliseconds, is rejected and 20 milliseconds is shaved from the leading edge of each coded "dit" and "dah." This provides the LED system with significant impulse noise rejection as well as an increased OFF time between the coded elements.

Modification of the code elements in this way can compensate, to some degree, for the eye's retentivity characteristic, which places the upper limit on visual code perception. **Figure 3** shows a simplified representation of how this functions. A more detailed analysis of the PND was presented in a previous article.[1]

general filter requirements

If you're concerned only about protecting your hearing from high noise pressure levels, steep skirts aren't required. A fourth-order bandpass filter designed for a nominal 50- to 100-Hz bandwidth, or a comparable 10- to 15-pole high-pass/low-pass combination adjusted to form a similar bandwidth, will do what is required. But if you wish simultaneous protection from high-level QRM that's very close in frequency to a desired signal and protection from wideband noise as well, an eighth-order bandpass — preferably in Butterworth or Chebychev configuration — is a minimum requirement.

The filter included in this article is an easy-to-build eighth-order Gaussian class design. An eighth-order Butterworth cascade was described in a prior article.[2]

Though the ringing performance of these narrow, steep-skirted filters can be a problem, they will allow comfortable copy to at least 25 WPM or so, depending on the individual. To mitigate the ringing and enable the use of filters that are still narrower, you can add a carrier-activated limiter between the output filter and power amplifier.[2] Clearly, as bandwidths narrow and as skirts fall more quickly, the visual tuning aid becomes more beneficial.

operating with sight and sound

To put this system into practice, turn your receiver's AGC off. Select a signal in the wideband position. As you tune through the beat note frequencies, you'll notice that the signal excites the LED only when it's in the narrow filter's bandwidth. Correlation between the LED and sonic outputs will be clearly recognized. As a corollary, if the wrong signal — that is, not the signal that you are focused on — is in the narrow filter's passband, the lack of correlation will be clearly perceived.

There isn't much question that copying code visually from a blinking LED is slower than copying by ear, but this system doesn't require that you copy with your eyes — only that you *sense* correlation. What's more, you don't have to actually watch the LED; peripheral vision is all you need. Of course, you'll probably look directly at the LED in the beginning, but you should be able to wean yourself from that habit reasonably quickly. Once you do this, you can put the LED anywhere it can be seen from the corner of your eye.

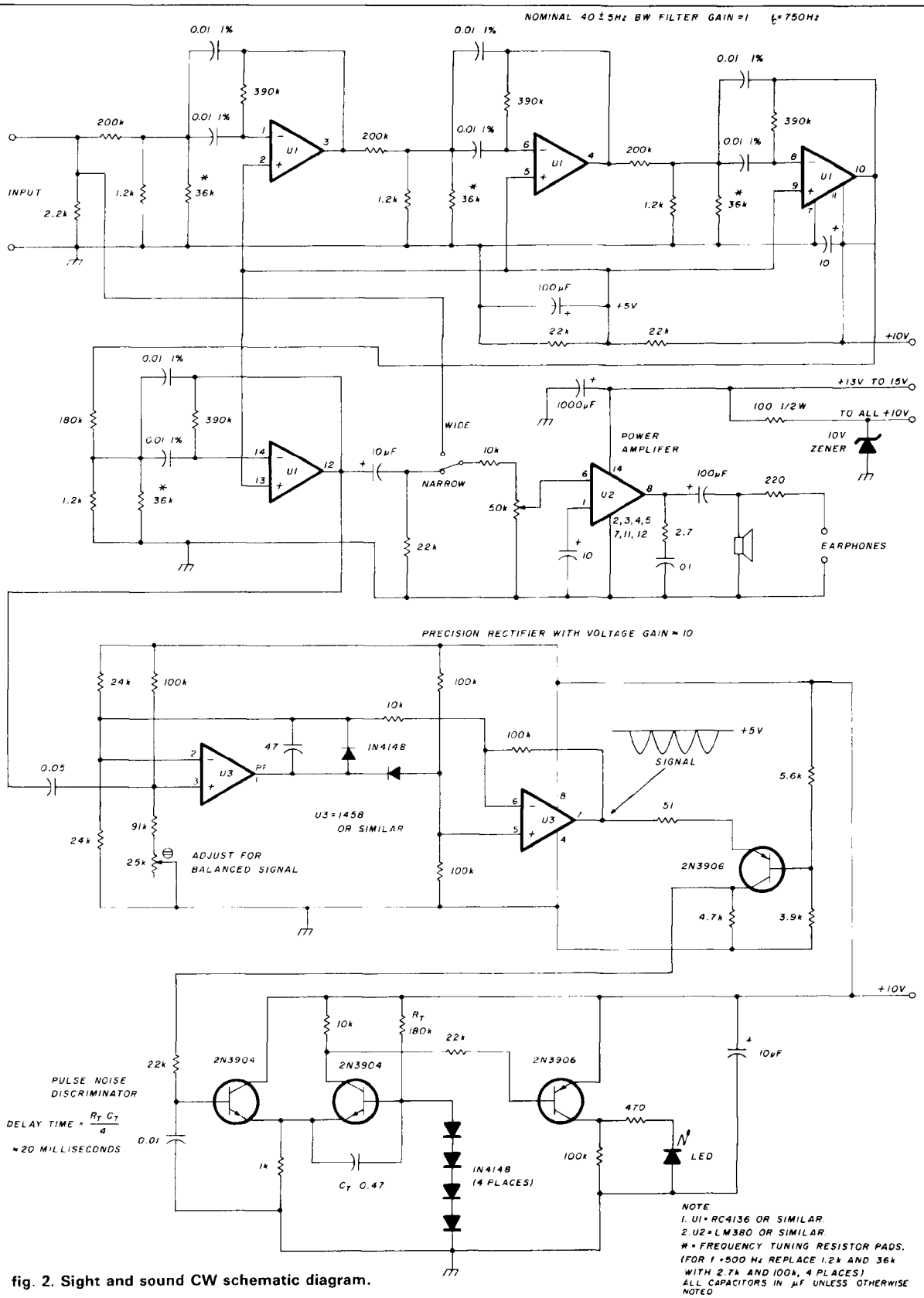


fig. 2. Sight and sound CW schematic diagram.

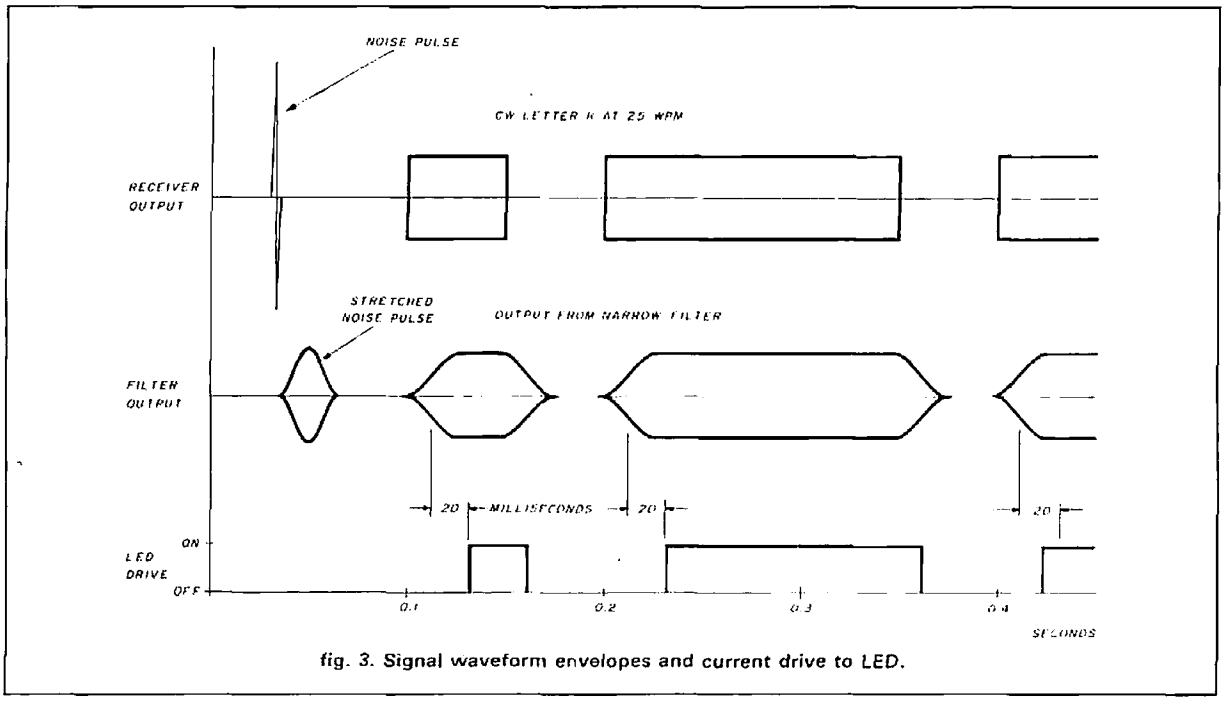


fig. 3. Signal waveform envelopes and current drive to LED.

When copying high-speed code, it may appear that the LED isn't keeping up to speed. This is an illusion. The problem isn't with the LED, but with our eyes, which just can't release light energy as fast as they can accept it. Under such circumstances, the OFF spaces tend to fill, making visual copy at high speeds extremely difficult. (This is what made 16 frame-per-second movies and TV possible.)

Besides the sonic benefit of the correlation function, there's a tuning "feel" assist. As you tune a signal while switched to the wider bandwidth, sonic feedback relative to knob control isn't lost. The end result is that the very critical knob control associated with very narrow filters is reduced. Once a signal is nicely in place, as indicated by the LED, you simply switch your audio to the narrow filter and you're right where you want to be.

In addition to these relatively mechanical improvements, there may also be some psychological benefits from parallel sensory excitation.[3]

Regardless of motivation, adding sight to sound in the detection of CW is relatively easy and inexpensive — and with your eyes, ears, and brain working together.

references

1. Don E. Hildreth, "A Pulsewidth Noise Discriminator," *ham radio*, November, 1984, page 23.
2. Don E. Hildreth, "Advanced CW Processor," *ham radio*, December, 1986, page 25.
3. Unpublished manuscript; send SASE to author for details.

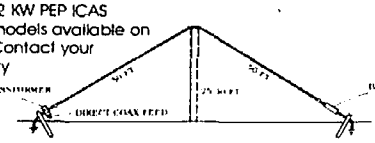
ham radio

CONTINUOUS COVERAGE ANTENNAS FOR COMMERCIAL & AMATEUR SERVICE

Model AC 1.8-30 — 1.8 to 30 MHz

- SWR Max 2:1, 1.4:1 average from 1.8 to 30 MHz
- Can be installed in approximately 80 ft. space
- Ideal for commercial services for multi frequency operation without the need for antenna tuners or additional antennas
- Handles 1 KW, 2 KW PEP ICAS
- Higher power models available on special order. Contact your dealer or factory

$159.50 SHIPPING & HANDLING ADD $4.00

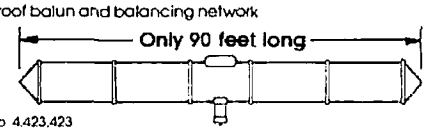


U.S. Patent No 4,511,898

Model AC 3.5-30 — 3.5 to 30 MHz

- SWR less than 2:1 from 3.5 to 30 MHz
- Complete assembled. Balun terminated with standard SO-239 connector
- Power capability 1 KW - 2 KW PEP ICAS. Higher power model is available on special order.
- Designed for 50 ohm feedline
- Weather proof balun and balancing network

$167.50 SHIPPING & HANDLING ADD $4.00



U.S. Patent No 4,423,423

ALL OUR PRODUCTS MADE IN USA

B&W BARKER & WILLIAMSON

Quality Communication Products Since 1932
At your Distributors. Write or Call.
10 Canal Street, Bristol, PA 19007
(215) 788-5581

a battery-backed master power system

Dependable dc power for normal and emergency operation

An ac power supply — whether it's just a simple series-requlated supply or a more complicated switching power supply — may add as much as 20 percent to the price of a single piece of today's solid-state equipment. A typical 20-amp power supply, for example, costs over $100. It also takes up space and generates heat. If it fails, your expensive equipment can suffer serious damage.

My station consists of four solid-state transceivers, a few solid-state linear amplifiers, a packet radio TNC, a memory keyer, and a 220-MHz transverter. All but the larger amplifiers, the packet CRT, and the rotor controls require 12 volts; if I were to purchase a power supply for each of the remaining items, the cost would exceed $400. Consequently, I've developed a power system that exceeds the ratings of any commercial supply, is totally backed up by a battery, and operates the station during total power failures for several hours. The system is safe, and its stability is very good.

The basic system, shown in **fig. 1.**, involves four blocks: the battery system, the battery charging system, the monitoring system, and the 12-volt distribution system.

• **The battery** is a "maintenance free" car battery purchased from a discount store for $29.95. I use standard battery clamps with a compression fitting to connect the large cables to the terminals. The terminals are protected with chemical pads to reduce corrosion. Mounted on a wooden surface — not directly on the cement floor — the battery is positioned away from anything that might come in contact with, and thereby short out, the terminals.

• **The battery charging system** is a homebrewed regulated power supply that I built using surplus computer power supply parts. Capable of providing up to +16 volts or currents of up to 75 amps continuous, it weighs over 100 pounds but costs very little to build. Though it could easily supply the radios by itself, I decided not to run it directly into them. The output voltage is fed to the battery through a large series diode that provides isolation from the battery when the ac power fails — whether because of a blown fuse or a general power failure. Mounted on a large heat sink and wrapped in insulation tape, this diode is rated at 100 amps and 100 PIV. Also in series with the battery and battery charger are a 25-amp quick-blow fuse and a current-measuring shunt that allows monitoring of the charging currents to the battery.

• **The battery monitoring circuitry** measures three parameters of the electrical system: the battery's terminal voltage (10 to 15 volts), the battery's input charge current (0 to 20 amps), and the battery's output current to the system (0 to 50 amps).

The battery terminal voltage monitor shown in **fig. 2** is composed of circuitry that provides metering from +10 to +15 volts. This allows me to use a 500-μA movement meter, on which each major graduation is equal to 1 volt. A 500-μA meter has an ohms-per-volt rating of 2000. This means that the amp meter is converted to a voltmeter by placing a series resistance of 2000 ohms per volt of desired range. Any internal resistance of the meter must be considered as part of this total resistance.

In order to get the meter to read from 10 through 15 volts, I biased the negative side of the meter to +10 volts by placing a three-terminal adjustable voltage regulator in series with the supply voltage and placing the output directly on the minus side of the meter. I could have used a precision voltage reference such as a temperature-compensated zener diode or a voltage reference. I chose values for setting the regulator to 10 volts to minimize voltage drift with aging and temperature.

Since I wanted to read from 10 volts up to 15 volts, the total range is 5 volts. Assuming 2000 ohms per volt, this translates into a total series resistance of 10,000 ohms. To ensure accuracy, I selected a 20-turn

By Eric L. Smitt, K9ES, 10 Bowling Green Lane, Worcester, Massachusetts 01602

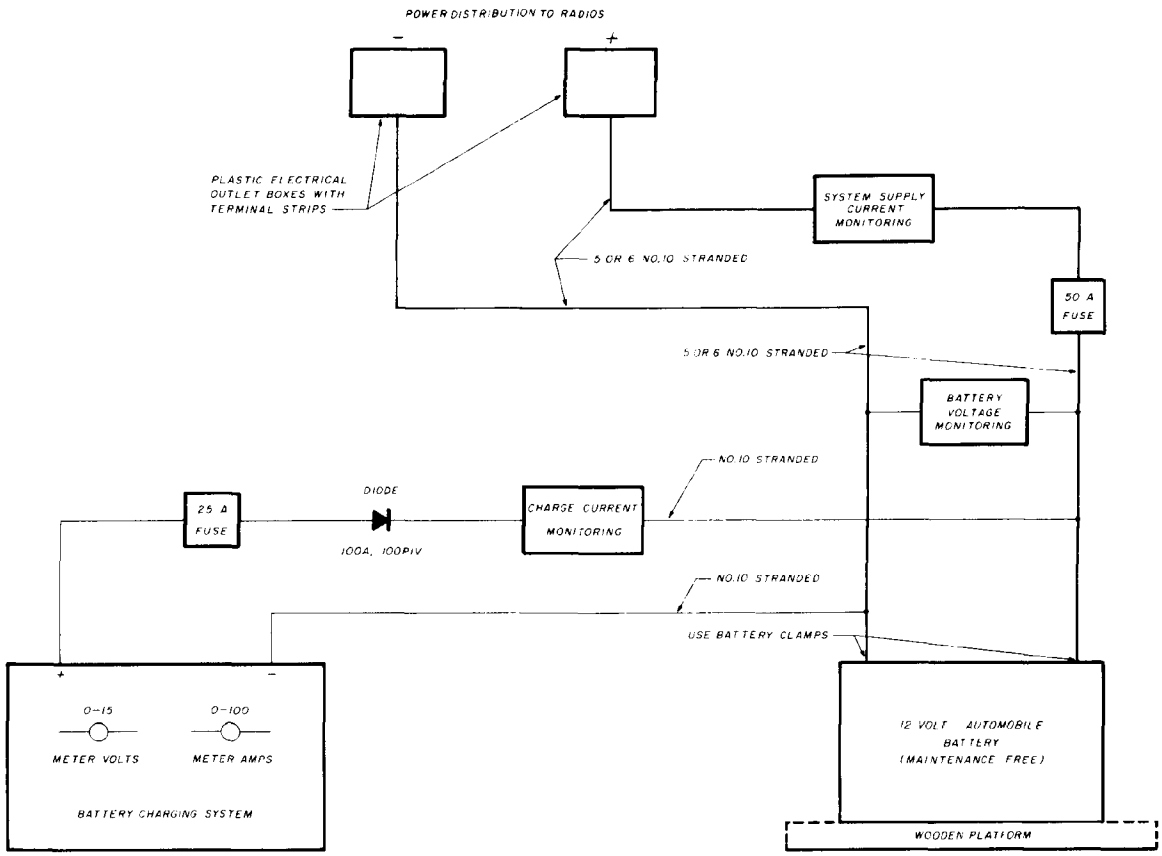


fig. 1. Master power system block diagram.

trim pot with a value of 10k and trimmed the resistance in series with the meter to make the meter agree with the reading of a digital voltmeter placed directly across the battery terminal. I routinely check measurement performance with my digital voltmeter, and find little, if any, voltage shift as time passes and temperatures change.

Current measuring of dc currents is done most easily with current shunts, or very small resistances, where series current produces a very small voltage drop, which is proportional to the amount of series current. I selected a criterion specifying that no shunt voltage drop would exceed 100 mV. To calculate the required resistances for the shunt, use Ohm's Law:

R = 0.1V / max amps

5/1000 ohms for 20-amp shunt

2/1000 ohms for 50-amp shunt

These resistances are *very* small, but with more high-current supplies available, resistor manufacturers are producing wirewound resistors with very low values. I found several 0.01-ohm, 6-watt, 5-percent wirewound resistors at a hamfest. To produce a 20-amp shunt (**fig. 2**), I paralleled two of these resistors together, using braid from RG-8 coax. To produce the 50-amp shunt, I paralleled five of these resistors together. The monitoring meters are actually 500-μA

meters, with series resistance to make them read from 0 to 100 mV.

The shunts must be mounted in the actual heavy wiring. The voltage pickup wiring can be a twisted pair going to the series resistance/meter units. The series resistance (including the meter resistance) for each meter is 200 ohms (remember 2000 ohms/volt). The actual series resistances were made using 20-turn, 100-ohm trim pots. Once the meter shunts and series elements were made, calibration was done with the DVM unit, connected to monitor large currents.

The power distribution circuitry is probably the most critical. All the best precautions taken to reduce voltage drop in shunts and maintain regulation of the system will be irrelevant if care isn't taken to use sufficient wire size. Stranded wire is a must in this application; solid copper wire is too difficult to work with in these sizes. Because of the currents that would result from a short, the wire must also be insulated.

I discovered that marine supply stores sell battery wiring for power distribution in boats. But because anything purchased through a marine supply store is likely to be very expensive, I decided to parallel six No. 10 stranded wires for each leg. I also placed a 25-amp series fuse between the isolation diode and the battery charging supply, and a 50-amp fuse (from a surplus dynamotor unit) between the battery and the radios. These fuses are very important, and must be included.

All wires in the positive and negative bundles are first soldered together and then to a large terminal strip mounted in a plastic electrical box. The positive plastic box and the negative box are separated by a distance of 5 inches in the hope of eliminating the possibility of short circuits. The terminal strips, also found at a hamfest, were selected to handle 25 amps per screw connection.

While all connections to the radios are made using compression-type screw lugs, I soldered the wires to the lugs and placed insulation over all exposed wire. I used the original wiring supplied by the manufacturer for each radio; these have in-line fuses to prevent damage to the system in case the radio fails.

A few words of caution are necessary. Do not omit the two fuses mentioned earlier. The 25- or 30-amp fuse will protect the battery if the charging fails, which would result in an overvoltage. The battery, which acts like a large capacitor, will consume as much current as you can supply; if you were to place a high voltage (above 15 volts) across its terminals, it would continue to accept charge until it exploded! Placing a fuse in series protects the battery and the radios if the charging supply fails (as it would, for example, if it were struck by lightning) and short out the regulator, leaving nonregulated voltage on the radios. Don't omit this fuse from your installation!

The 50-amp output fuse protects against a short circuit's delivering enough current to melt the wiring. Remember that the battery has a "cold cranking output" rating of several hundred amperes, which can

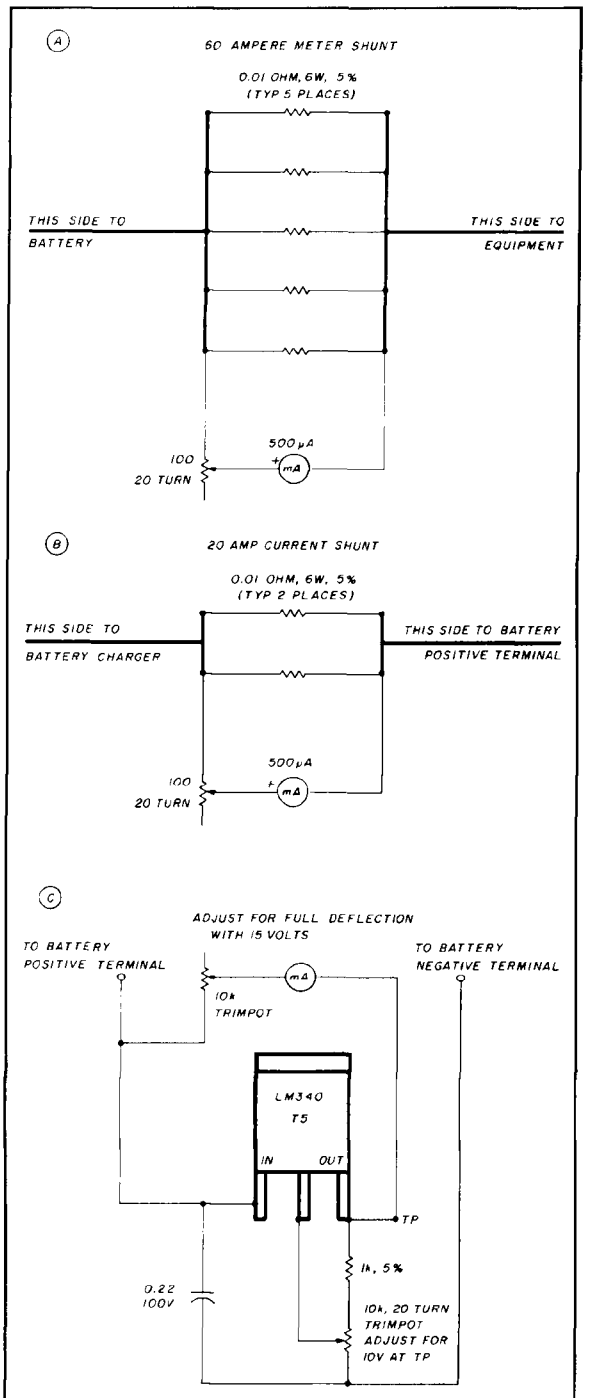


fig. 2. System monitoring schematics: (A) supply current monitoring; (B) charge current monitoring, (C) battery voltage monitoring.

Join AMSAT...Today

Amateur Radio Satellite OSCAR 10 provides:

- **A New Worldwide DX Ham Band** open 10 hours a day.
- **Rag Chew With Rare DX Stations** in an uncrowded, gentlemanly fashion.
- **Popular Modes In Use:** SSB, CW, RTTY, SSTV, Packet
- **Full Operating Privileges** open to Technician Class licensee or higher.

Other AMSAT Membership Benefits:

Newsletter Subscription:
Dependable technical articles, satellite news, orbital elements, product reviews, DX news, and more.

Satellite Tracking Software
Available for most popular PCs.

QSL Bureau, AMSAT Nets, Area Coordinator Support, Forum Talks

Construction of Future Satellites For Your Enjoyment!

AMSAT Membership is $24 a year, $26 outside North America. VISA and MC accepted.

AMSAT
P.O. Box 27
Washington, DC 20044

301 589-6062

111

melt wire and start a fire. The battery will overheat, and perhaps explode. Don't omit this fuse, either.

Some of my friends are reluctant to use a lead acid battery in the ham shack because they worry about hydrogen gassing and the possibility of explosions resulting from gases mixing near an open flame. These problems are real! But you can avoid gassing by limiting the battery voltage to 13 volts (or less). Your transmitted output power will be slightly lower, but your radio will still work well, and the battery life will easily exceed several years.

Avoid charging the battery to a level at which you hear the sounds of gassing. This bubbling noise is the first indication that you're producing excess hydrogen gas. Keep the voltage below the point of gassing or replace the battery if gassing occurs with a battery terminal voltage near 13 volts.

Remember, too, that car batteries contain sulfuric acid. Every time you work near the battery, wash your hands and launder clothing that might have touched any liquid near the battery. Keep a barrier between you and the battery in case it explodes. Don't smoke or allow any open flame near the battery. Hydrogen gas will rise, but don't let it accumulate by covering the battery in an airtight enclosure. And don't place the battery on a cement surface; the calcium in the floor will cause the battery to die!

first aid

If acid contacts your skin, wash the affected area with a large volume of water immediately. Spread a mixture made of baking soda and water on the affected area and seek medical attention if the area is large or if the skin is burned. If acid gets into your eyes, rinse them thoroughly in the shower and get to a hospital *immediately*.

Should acid get on your clothing, remove all contaminated items and wash all exposed skin. Then soak the clothing in water mixed with baking soda. Sulfuric acid will destroy cotton clothing.

Remember that battery acid is very dangerous. Use all appropriate precautions whenever you work with batteries.

how well does it work?

During the 1987 VHF QSO Party we lost power in our neighborhood when a severe thunderstorm knocked out a transformer. I stayed on the air during the 2-hour blackout — in the dark! (My next investment, obviously, will be an automatic lighting system that turns on automatically whenever I lose ac power to the shack.

I've had my IC-751, IC-551D, IC-271A, IC-471A, KLM 160-watt 2-meter amplifier, and my MMT-220/28 on the air, all at once, without difficulty. It works!

ham radio

new uses for old tv tuners

Don't throw them away — put them to work in a variety of handy applications

Like any other tuner, the TV tuner is the front end of a receiver — and it's the front end, of course, that determines which frequencies a receiver will hear. Used ahead of a low-band receiver, the TV tuner becomes a VHF/UHF converter for that receiver.

Typical VHF TV tuners cover a frequency range of 54 to 216 MHz and UHF TV tuners cover 420 to 900 MHz. Think of the ham bands that are either covered by or adjacent to those ranges; some (220, 450, and 902 MHz, for example) are within the tuning range of stock tuners, and others (6 and 2 meters) are adjacent. Still other bands may be reached with some modification of the tuner.

It doesn't take much to get the tuner operating as it was designed, and it's always best to do this before beginning any modification. Getting the tuner working requires applying the appropriate voltages and feeding the i-f output to a receiver tuned to 47 MHz. A signal generator with a known signal or harmonic in the desired frequency band makes the retuning operation much easier. Once the unit is operating, check the frequency coverage to determine what you'll have to do to move its coverage to the desired band.

TV tuners come in many sizes and shapes, but fall into three basic categories: detent, variable, and varactor. Detent tuners have a band switch and a fine tuning adjuster. Variable tuners use a tuning capacitor to cover the entire tuning range. Varactor tuners use varactor diodes as tuning capacitors for band coverage. A voltage is applied to the varactor diode to change its capacitance; the higher the voltage, the lower the capacitance, and vice versa.

intermediate frequency

When a TV tuner is used as a converter, its i-f output is fed into a receiver's antenna input. The receiver then operates as the tuner's i-f amplifier and detector. The i-f frequencies vary according to the date of manufacture and the type of application for which the tuner was designed. Black-and-white tube TV sets built from about 1947 through 1957 used an i-f of 21 to 27 MHz, while color sets have an i-f centered at about 47 MHz. Cable TV and VCR tuners have an i-f of 63 MHz (channel 3), with a bandwidth of approximately 6 MHz. If the tuner is solid-state, it will probably have an i-f of 47 MHz unless it's from a VCR tuner.

Many suitable receivers are available for operation in the 47-MHz region. Receivers for 30- to 50-MHz communications and scanning are quite common and work well with TV tuners. Some Amateur receivers also cover 47 MHz.

When using an Amateur receiver with a narrow passband, it will be necessary to tune the receiver across the i-f frequency after the tuner has been set to a desired frequency. *Note that frequencies tuned by the receiver will be reversed from the normal tuning scheme.* Most TV tuners have the local oscillator frequency set above the incoming RF. This means that a direct frequency translation does not occur, and the incoming frequency decreases as the receiver's dial frequency increases.

The tuning reversal is caused by the fact that the tuner's oscillator frequency is fixed above (i.e., higher than) the RF input frequency. With the i-f being tuned to a higher frequency, the frequency difference between the RF and the i-f decreases.

applying power

Before applying power, it's necessary to examine the tuner and identify all of the terminals. If possible, remove the cover(s) to expose the wiring; this will help in identifying the connections.

The antenna input terminal(s) will be obvious as either two pins or a phono connector. Some UHF varactor tuners use a single pin for an antenna input. When several other phono connectors appear in addition to the antenna input, one may be used as the i-f output and another may be used as the UHF tuner i-f input. The UHF tuner input provides a means of tying the UHF signal into the i-f through the channel selector switch. For ham converter purposes, the UHF input connector may be ignored.

There are five important terminals on most tuners for voltage application: V_{CC}, (sometimes marked B+; AGC; AFC (found only on more recent models); band switch (discussed under "varactor tuners," below);

By Hugh Wells, W6WTU, 1411 18th Street, Manhattan Beach, California 90266

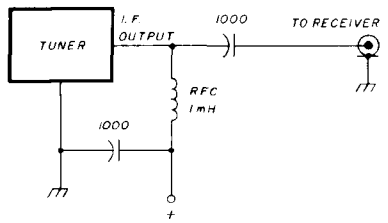


fig. 1. Method of applying power to the mixer when required.

sitivity. A 5- to 10-foot wire attached to the ungrounded antenna terminal should be adequate.

Voltage applied to the AGC terminal (normally positive with respect to the case) will control the tuner's sensitivity, and when varied with a potentiometer, will function as an RF gain control. A fixed voltage may be applied later on. With the tuner and receiver operating, tune to a known signal (TV or otherwise) and adjust the AGC voltage from (+)0 to 10 volts for maximum received signal (measure and record the AGC voltage value for future reference).

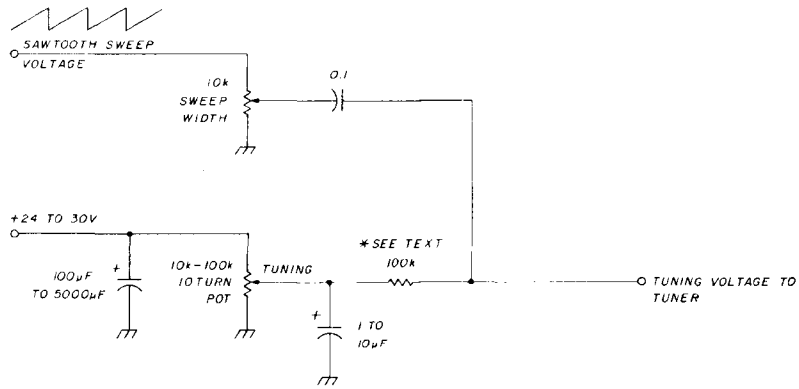


fig. 2. Tuning and sweep voltage circuit for varactor tuners.

and i-f output. Tube TV tuners also have a tube heater terminal which is usually 6.3 volts, but it may be another voltage value if the tuner was designed for use in a series string heater circuit. For solid-state tuners, the voltage required for V_{cc} is (+)15 to 20 volts; for AGC, it's (+)0 to 5 volts. The i-f output terminal is either a wire or a phono connector. If the output is a wire, it will protrude through the tuner wall and may be attached to a terminal strip mounted on the tuner's case. For most tuners used as converters, this i-f wire may be connected directly to the center conductor of a coax feeding the antenna terminal of the receiver.

A few tuners require a voltage to be applied to the i-f wire to provide power to the transistor/tube mixer (see **fig. 1**). Determine the need to apply power before actually doing so to reduce the risk of circuit damage. Measure the resistance between the i-f wire and the transistor collector or tube plate. If the resistance value is below 50 ohms, power is probably required.

Attach an antenna to the tuner's antenna terminals to obtain an input signal from any source. Even though most tuners have a 300-ohm balanced antenna input, grounding one terminal and feeding the other with 52-ohm coax seems to have little effect on signal sen-

tuning aids

Make a set of tuning aids to assist in making coil adjustments during frequency modifications. Small metal rods (1/16 inch diameter x 1/4 inch long) attached to a plastic or wooden stick are useful tools for adjusting VHF and UHF coils. Brass, a diamagnetic material, will reduce the coil's inductance when inserted. Inserting the metal can also increase the circuit capacitance, but the net result will be an increase in the resonant frequency. Inserting an aluminum rod of similar size will lower the resonant frequency slightly. Aluminum, being nonmagnetic, won't affect the inductance value, but will increase the circuit capacitance, causing a lowering of the resonant frequency. An iron rod, being magnetic, will increase the inductance value and lower the resonant frequency; a powdered, rather than solid, iron rod would be preferable at VHF and lower RF frequencies. Brass and aluminum rods, however, have been found to be the most useful in working with VHF and UHF tuner modifications.

These tools are used to determine if any improvement is to be gained by coil adjustment *before* the adjustment is actually made. For example, if the signal strength of the incoming signal is improved as the

brass rod (as opposed to aluminum) approaches the coil, then the inductance value should be reduced slightly. A signal improvement with either aluminum or iron indicates that an *increase* in inductance is required.

detent tuners

Detent tuners for the VHF bands use either a drum or switch mechanism for changing channels. On this type of tuner, a fine-tuning adjustment is provided by either of two means: by oscillator slug adjustment or by a dielectric tuning capacitor that changes the oscillator circuit capacitance.

Putting the detent tuner into one of the ham bands may require modification of the coils. You'll need a signal generator of some kind to track the effects of retuning; it doesn't take much adjustment for most tuners to move over into adjacent ham bands.

As an example, let's assume that you want to modify a tuner for 6 meters. Select channel 2 (54 to 60 MHz) on the tuner. Adjust the fine tuning for the lowest frequency. Using a signal source, locate the tuner's input frequency. If it's already in the ham band, no modification is necessary. If it has to be lowered a bit, try increasing the tuner's oscillator trimmer capacitance, squeezing the oscillator coil wires together, or adding an additional turn of wire to the coil.

The channel 2 oscillator coil will be the easiest to identify because it has the greatest number of turns of those on the oscillator wafer switch. Increasing the inductance — either by squeezing the coil or adding a turn of wire — will lower the frequency sufficiently.

Retuning of the tuner's input circuits is usually necessary. However, the oscillator coil must be retuned and put on the desired frequency before the RF and mixer circuits are touched. It's important to tune and measure only one circuit at a time during the modification.

varactor tuners

Of the three types of tuners, varactor tuners provide the most flexibility for Amateur use because the tuning range is generally continuous and may overlap the ham bands without modification. Cable-ready VCR tuners, for example, cover about 39 to 290 MHz. Frequency coverage of 6, 2, and 1-1/4 meters is available without tuner modification. UHF varactor TV tuners cover the top part of the 450-MHz band and will require modification to cover the 902-MHz band. A signal source is necessary when modifying tuners for these bands.

Modifying the tuning frequency of a varactor tuner requires a change in the inductance value of the oscillator. But because space is tight, capacitor changes are difficult to make. To move a VHF tuner up to 220 MHz, it's necessary to decrease the induc-

HIGH PERFORMANCE PRESELECTOR-PREAMP

The solution to most interference, intermod, and desense problems in **AMATEUR** and **COMMERCIAL** systems.



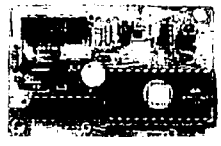
- 40 to 1000 Mhz - tuned to your frequency
- 5 large helical resonators
- Low noise - High overload resistance
- 8 dB gain - ultimate rejection > 80 dB
- 10 to 15 volts DC operation
- Size - 1.6 x 2.6 x 4.75" exc connectors
- **FANTASTIC REJECTION!**

Typical rejection:
±600 Khz@144 Mhz: –28dB
±1.6 Mhz@220 Mhz: –40dB
±5 Mhz@450 Mhz: –50dB

Price - CALL bipolar w/RCA jacks
Connector options: BCN $5, UHF $6, N $10
SUPER HOT! GaAs Fet option $20

AUTOMATIC IDENTIFIERS

ID-1





ID-2

- For transceivers and repeaters - **AMATEUR** and **COMMERCIAL**
- Automatic operation - adjustable speed and amplitude
- Small size - easy installation - 7 to 15 volts DC
- 8 selectable, reprogrammable messages - each up to 2 min. long
- Wired, tested, and programmed with your message(s)

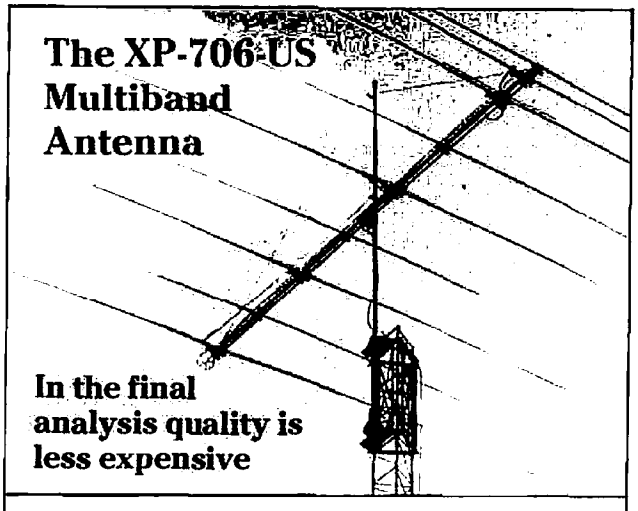
Model ID-1 - $49.95 Model ID-2 w/2 to 10 minute timer - $69.95

We offer a complete line of transmitter and receiver strips and synthesizers for amateur and commercial use.
Request our free catalog. *Allow $2 for UPS shipping - Mastercard and VISA welcome*

GLB ELECTRONICS, INC.
Dept H, 151 Commerce Pkwy., Buffalo, NY 14224
716-675-6740 9 to 4

116

The XP-706-US Multiband Antenna



In the final analysis quality is less expensive

The unique design of the XP-706-US antenna system gives you MONOBAND PERFORMANCE in a Multiband beam. The antenna *USES NO TRAPS* of loading coils that rob power and limit bandwidth. Sommer Antennas use the FULL surface area of the elements on ALL bands.

Our commitment to use only the finest materials insures that your investment will last for years. Our system uses a Double rectangular boom, CAST aluminum element mounting brackets, all stainless hardware and a high power balun.

Monoband performance on a *Multiband* beam is yours when you move up to Sommer, the last beam you'll have to buy. We believe Sommer is your best antenna value when *compared to the construction and performance of other multi and monoband antenna systems.*

H.J. Theiler Corp.
P.O. Box 5369
Spartanburg, SC 29304
(803) 576-5566

SOMMER

117

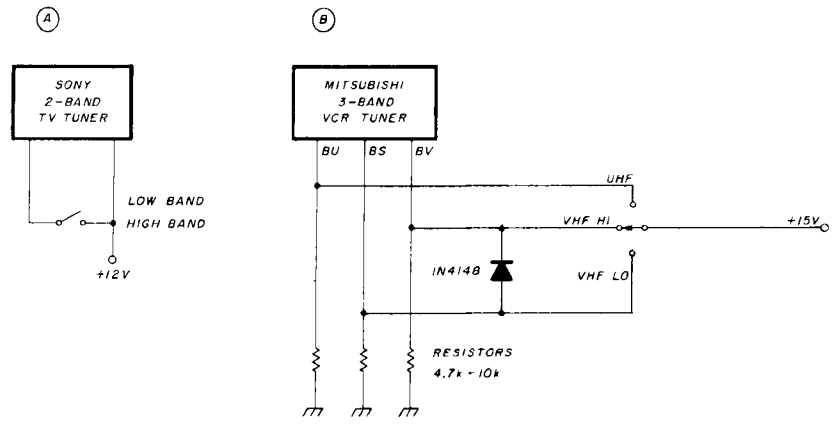


fig. 3. Band selection methods for varactor tuners: (A) Sony two-band tuner, (B) Mitsubishi three-band tuner.

tance of the oscillator coil by spreading the coil wires slightly. Once on frequency, the front end (RF and mixer) coils may be tweaked to improve the overall sensitivity. Be sure to use the brass or aluminum tuning aid before modifying the coils significantly.

Tuning is accomplished by providing a variable tuning voltage from 0 to 30 volts. The most satisfactory tuning resolution is obtained by using a ten-turn potentiometer to provide the vernier voltage adjustment (see **fig. 2**).

One of the greatest problems observed with the varactor tuner occurs when the oscillator frequency-modulates as a result of voltage fluctuation on the tuning voltage line and power supply bus. A fairly large capacitor (e.g., 1 to 10 μF) placed on the tuning voltage line will reduce this tendency. Shielding the line and regulating the power supply bus will help, too. Adding the large capacitor reduces the tuning slew rate. You'll overshoot the desired frequency if you turn the tuning knob too rapidly.

The 100-k resistor between the potentiometer and tuner is optional unless the circuit is to be used as a spectrum analyzer.

If the tuner has two or more bands, frequency selection is accomplished by diode switching within the tuner. Switch control is obtained by applying a voltage to the appropriate diode(s). For example, I tried the scheme shown in **fig. 3A** on a Sony two-band VHF TV tuner. When the high band was selected, a positive voltage was applied to both terminals; when the low band was chosen, voltage was applied to only one. The actual voltage required for switching didn't seem to be critical on the Sony tuner as long as it was kept between 8 and 14 volts. However, the greatest signal sensitivity occurred at +12 volts.

A Mitsubishi VCR tuner had three band switch terminals. **Figure 3B** shows the circuit developed for selecting its bands. The selection voltage had to be +15 volts for maximum signal sensitivity, and when not used, the terminals had to be pulled to ground (a soft pull-down was sufficient, but floating the terminal failed to work). This particular tuner had independent AFC and tuning voltage terminals. Apparently fixed voltages were established for band selection and rough channel tuning. An AFC voltage was then applied for fine tuning.

variable tuners

In some tuners, a variable capacitor provides the means of tuning through the channels. Variable UHF tuners have been around the longest and are generally the most readily available. Mechanically, they're difficult to tune by rotating the shaft when they're used with narrowband receivers following them. Once tuned, however, they seem to be quite stable. Unfortunately, very few of these tuners have RF stages, and their sensitivity suffers for weak-signal activity. A good outside antenna and/or RF pre-amp is suggested as a means of improving performance.

The circuit of the tuner is very basic, with one or more passively tuned circuits ahead of a diode mixer. Each one of the tuning sections is a coaxial cavity with a capacitor at the top of the coaxial line. A transistor oscillator provides the injection signal for mixing. Power supply voltage stability for the oscillator is critical, although the actual voltage value is not. Most will operate very well on a 9-volt transistor battery. Some tuners of this type also have varactor diodes in their oscillator circuits to accommodate AFC. Examine the lead(s) attached to the diode for polarization; occasionally, both ends of the diode are brought out of the case. The cathode end (the end with a stripe) will be attached to the positive source and the anode end will be attached to ground. A tuning voltage applied to

the diode provides fine-tuning control around the frequency selected by the tuning capacitor (see the technique used in **fig. 2**).

The tuning range of the UHF variable tuner generally covers the top end of the 450-MHz band up to 890 MHz. Modification of the tuner would be necessary if you wanted to reach the 902-MHz band, but this would take the tuner out of the 450-MHz band. The oscillator, for most tuners, is on the high side of the RF input. Therefore, before making any modification, be sure to verify the placement of the oscillator above or below the RF input. Verification is accomplished at the lowest frequency. Adjust the tuner to the lowest frequency possible and locate the RF input frequency with a signal source. Once you find it, increase the signal source frequency up 94 MHz (two times the i-f, 47 MHz), which is the detected RF frequency plus 94 MHz. If the signal is heard — even though it may be weak — the oscillator is probably above the input. Return to the previous RF input frequency and decrease the signal source frequency by 94 MHz (detected RF minus 94 MHz). If the signal isn't heard, then the oscillator is on the high side. Should the signal source be heard on both sides, shift the tuner to a new frequency and run the test again, since you're hearing generator harmonics or spurs on one side.

Another technique used for identifying the tuner's oscillator placement is varying the received i-f frequency. This technique works when a tunable receiver follows the tuner. Locate the RF input frequency with the signal source and adjust the frequency dial for peak signal into the receiver. Take note of the receiver's dial frequency. Then increase the signal source frequency by a few kHz. Re-tune the receiver dial to receive the signal again and note the new frequency indication. If the frequency is lower, the tuner's oscillator is *above* the incoming RF. If it's higher, the oscillator is *below* the incoming RF. Repeat the technique a few times for verification.

Assuming that the oscillator is on the high side of the RF, two choices are available for 902 MHz tuner modification. The first choice requires moving the oscillator up about 30 MHz, with modifications to the RF and mixer circuits made later. The second choice requires leaving the oscillator where it is and modifying the RF and mixer circuits by moving them up 94 MHz, placing them above the oscillator. The first choice is probably easier, although the oscillator may stall or become sluggish at the higher frequency (the oscillator transistor is approaching 1000 MHz).

The modification may be as simple as reducing the fixed capacitance in the oscillator circuit. The fixed capacitors are wires or metal tabs attached by one end to the walls near the top end of the cavity. Bending them against the wall, away from the tuned line, reduces the capacitance and may be the only tweaking required. Check the new oscillator frequency before modifying the RF and mixer circuits. If the oscillator frequency is at the desired frequency, bend the mixer wire/tabs against the wall while monitoring for a peaked signal level transferred through the tuner. You can use a plastic or wooden stick to bend wires while the circuit is operating, but you'll have to remove it from the circuit to assess the effects of the adjustment. Then move on to the RF circuit and repeat the peaking process.

For the second choice, retuning the RF input and mixer circuits will put them above the oscillator by 47 MHz. Raising the frequency of the cavity requires shortening the cavity or reducing the capacitance at the top. One modification technique requires the removal of capacitor plates to raise the cavity frequency by 94 MHz. If possible, avoid removing the variable capacitor plate; once removed, the plates cannot be reinstalled.

The output of the diode mixer may be connected directly to the coax center conductor going to the receiver. But you'll have to determine if signal sensitivity improves when you shunt the coax with a 10- to 22-k resistor. The diode requires a dc current path for proper mixing action to take place. You can place a 10- to 22-k, 1/4- or 1/8-watt carbon resistor inside the mixer cavity near the i-f output. One end of the resistor is soldered to the i-f output connector wire from the diode. The other end of the resistor is soldered to the case ground. An alternate method is to place a coaxial "tee" in the i-f line going to the receiver. A resistor is shunted across the center lead and shield at one of the ports of the "tee."

tubed tuners

Tubed tuners will be either detent or variable types and will require a power supply voltage, B+, of 80 to 150 volts, with 100 to 105 volts preferred. The proper heater voltage will also be necessary. Tubed tuners frequently require that the mixer plate voltage be supplied through the i-f output circuit. In the absence of an output transformer, a 1-mH RF choke connected between the i-f output lead and B+ will provide the power (see **fig. 1**). Signal output can then be coupled from the lead through a 1000-pF capacitor to the center conductor of the coax going to the receiver.

Fortunately, tubed TV tuners don't require an AGC voltage for proper operation. But for maximum signal sensitivity, the AGC lead should be grounded, not left floating. The addition of a negative voltage variable from 0 to 10 volts will function as an RF gain control.

Because of their bulk, tubed tuners are fairly easy to modify. But because of their age, most tubed tuners cover 50 MHz, 146 MHz, and 220 MHz within the oscillator's tuning range for the selected band.

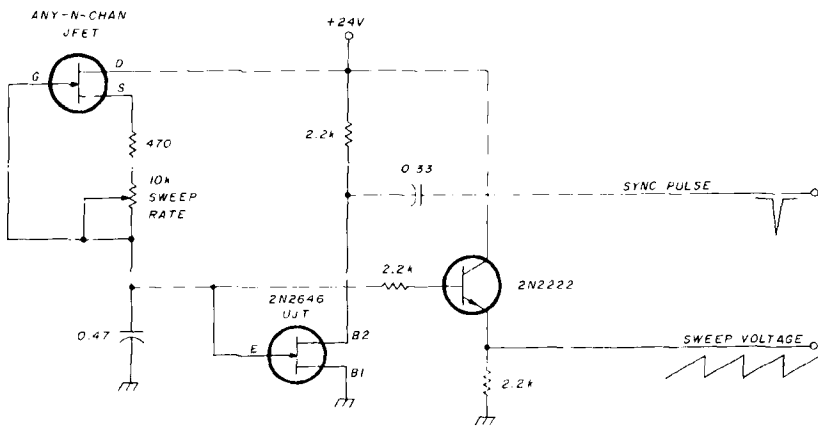


fig. 4. Sawtooth sweep generator.

In the past, the Amateur's favorite was the Mallory Inductuner (circa 1949), which used three spiral-wound inductors covering 50 to 220 MHz in two bands. By disabling the band switch that caused the tuner to jump over the 88- to 175-MHz band segment, you could modify the tuner to cover 2 meters.

A detent favorite was the Standard Coil drum tuner (circa 1952). All of its coils were mounted in clips to form a drum; removing all except the one being worked on provided ample room for modification. Later model tuners used a 6BQ7/6BZ7 cascode RF stage that provided excellent weak-signal sensitivity.

power supply

The power supply requirements are generally the same for all solid-state tuners. However, since voltage fluctuations and hum cause the local oscillator to frequency-modulate, a well-regulated and filtered power supply is an absolute *must*. Any of the popular three-lead, fixed-voltage regulators are quite satisfactory for use with TV tuners. Variable voltage regulators such as the LM723 and LM317 allow users to select voltage values.

The typical solid-state tuner V_{cc} voltage requirement is (+)15 to 20 volts (50 to 100 mA). Varactor tuners also require a 24- to 30-volt (5 to 10 mA) regulated source for tuning control, and possibly 12 to 15 volts (10 to 20 mA) for band switching. Some tuners, such as the UHF variable tuner, will operate satisfactorily on a 9-volt transistor battery. Battery life is determined by the amount of current drawn by the particular tuner.

Oscillator stability, the most important factor, depends on thermal heating and voltage variation. Regulation and low V_{cc} line impedance are key factors in reducing the oscillator's tendency to frequency-modulate. Taking advantage of the oscillator's sensitivity to voltage variations, small adjustments in V_{cc} may be used to provide a fine-tuning capability. A V_{cc} tuning control can be implemented by placing a low-value potentiometer in the regulator voltage sense circuit of one of the variable voltage regulators. Small changes in potentiometer resistance will cause small changes in the V_{cc} value, which will result in an oscillator frequency shift.

applications

Low-band communications receivers (30 to 50 MHz) appear to be inexpensive items at ham swap meets, perhaps because of diminished interest in low-frequency activity. In general, the low-band receivers were well designed and continue to perform adequately. Adding a TV tuner as a front end converter can provide such receivers with new life.

Variable or varactor tuners are preferred for use with fixed-frequency receivers because of their tuning capability. Detent tuners would work well also, but would be limited to single-channel monitoring.

When used with scanning receivers, TV tuners function as converters to extend the received frequency coverage. One of the advantages of using a scanning receiver lies in the fact that the TV tuner i-f may be scanned from about 43 to 48 MHz, allowing the selected input frequency of the tuner to be scanned over a 5-MHz segment. The tuner's RF frequency is adjusted during the initial setup of a band and then left alone. Tuning occurs by scanning the i-f. Detent tuners work well in this application.

One of the better uses of wide-frequency range receivers is as a spectrum analyzer. Together in such an application, the varactor tuner, a 30- to 50-MHz communications receiver, and an oscilloscope functions as a spectrum analyzer. The receiver's first limiter

dc output (or last i-f, if sufficient scope gain is available) is connected to the vertical input of the scope, providing a voltage amplitude display as a function of signal strength. The limiter output of a tube-type receiver swings negative, causing the scope display to swing downward unless the scope input can be switched to negative. A negative swing, as opposed to a positive swing, on the scope is of little consequence unless one'e eye cannot adjust to the downward display of the signal.

To provide a frequency display on the horizontal axis, the varactor tuner must be swept over a range of frequencies with a sawtooth waveform. This may be accomplished in one of two ways: by obtaining the sawtooth sweep voltage from the scope or by generating a sawtooth voltage external to the scope. Older model Tektronix scopes had a sweep output terminal on the front panel that provided ready access to the internal sawtooth sweep voltage. The voltage output from the scope terminal was quite high, however — usually up to 100 volts. Approximately 0 to 3 volts is all that's required for adequate tuner sweeping. A resistor in series with a potentiometer will ratio the sweep voltage to the desired amount.

Should the user's scope not provide a sawtooth output voltage, an external sweep generator (**fig. 4**) may be used. A sync pulse is provided by the circuit to trigger the scope so that the trace will sweep and track along with the tuning voltage to the tuner. Some horizontal nonlinearity will be observed in the analyzer display. However, the amount is tolerable. The effect is caused by the difference in sawtooth linearity characteristics between the scope sweep and the external generator. Obtaining the sweep from the scope masks most of the effects of sweep nonlinearity. The remaining nonlinearity in the display is caused by the non-uniform voltage-to-frequency conversion of the varactor diode.

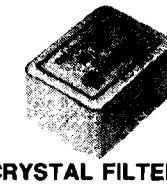
The sawtooth voltage is used to drive the tuning voltage line (see **fig. 2**) of the tuner in sync with the scope sweep, resulting in a signal voltage versus frequency display on the scope. Controlling the tuner frequency and sweep width separately allows the tuner to "look" at single or multiple signals near the center of the tuner's frequency setting.

The narrow passband of the typical 30- to 50-MHz receiver makes the tuning of the TV tuner critical but still satisfactory for analyzer work. However, a wider passband receiver makes the spectrum analyzer easier to handle. Readers who want to build a wider passband receiver, are referred to K4IPV's article, "Poor Man's Spectrum Analyzer," which appeared in the September 1986 issue of *ham radio*.

TV tuners are available from Science Workshop, P.O. Box 393, Bethpage, New York 11714. — Ed.

ham radio

K.V.G. CRYSTAL PRODUCTS



9 MHz CRYSTAL FILTERS

MODEL	Application	Bandwidth	Poles	Price
XF-9A	SSB	2.4 kHz	5	$61.00
XF-9B	SSB	2.4 kHz	8	83.00
XF-9B-01	LSB	2.4 kHz	8	110.00
XF-9B-02	USB	2.4 kHz	8	110.00
XF-9B-10	SSB	2.4 kHz	10	145.00
XF-9C	AM	3.75 kHz	8	89.00
XF-9D	AM	5.0 kHz	8	89.00
XF-9E	FM	12.0 kHz	8	89.00
XF-9M	CW	500 Hz	4	62.00
XF-9NB	CW	500 Hz	8	127.00
XF-9P	CW	250 Hz	8	175.00
XF-910	IF noise	15 kHz	2	21.00

10.7 MHz CRYSTAL FILTERS

WRITE FOR FULL DETAILS OF CRYSTALS AND FILTERS
Export inquiries Invited. Shipping: $3.75

ANTENNAS

2M:
10XY-2M $80.00

70cm:
70/MBM28 60.00
70/MBM48 90.00
70/MBM88 120.00
DY20-900 MHz 80.00

LOOP YAGIS
1268-LY $60.00
1296-LY $60.00
1691-LY $75.00
order loop yagi connector extra

Send 66¢ (3 stamps) for full details of all our VHF & UHF equipments and KVG crystal products.
Shipping: FOB Concord, Mass.
Prices subject to change without notice

MasterCard VISA

Si

(617) 263-2145
SPECTRUM INTERNATIONAL, INC.
Post Office Box 1084
Concord, MA 01742, U.S.A.

123



INTERNATIONAL MONTHLY MAGAZINE BY AND FOR ACTIVE RADIOAMATEURS

Radiosporting

THIS IS IT! - FOR BIG GUNS & LITTLE PISTOLS

A magazine dedicated to quality and sportsmanship in amateur radio operating. Fresh, timely, practical and down to earth reading for little pistols and big guns. Written by the world's best in their fields: ON4UN, SMØAGD, LZ2CJ, VE3BMV, KH6BZF, DJ9ZB, ZS6BRZ, W1WY, N2AU, K7GCO, K4ZN, W4GF, VE3JTQ, WB4ZNH, WB9TBU, KQ2M, NS6X, W3FG, KA3B, K1PLR, N7CKD, VE3XN, ABØX, JE1CKA and others.

Includes DX News, QSL Info, 160m, 80m, 10m, 6m columns, DXpeditioning, Propagation, Awards, Contest rules and results, Traffic - Emergency, FCC News, New Products, Antennas, Technical news and articles, equipment reviews and modifications, computer programs, Radio Funnies, Club Life, RTTY, VHF/UHF, Mail Box, Classified Ads and much more in a magazine format with the speed of a bulletin.

RADIOSPORTING sponsors DX Century Award, Contest Hall of Fame and World Radio Championship contest.

"Your publication is superb! Keep it up!" **Joe Reisert, W1JR**

"Your W2PV articles are priceless. Your magazine is super!" **Rush Drake, W7RM**

"Let me congratulate you on a very impressive magazine. Just what I've been looking for as a DXer and Contester!" **Dick Moen, N7RO**

"RADIOSPORTING, once received, cannot be tossed aside until it is read from cover to cover. Then reviewed again and again." **Chas Browning, W4PKA**

Subscription rates: 1 year USA $18, Canada CDN$26, Overseas US$23; 2 years $33, $48, $42 respectively. Single issue $2.
USA First Class Mail add $8/year, DX Air Mail add $15/year.

TRY US! SUBSCRIBE OR SEND $1 FOR YOUR SAMPLE COPY.
RADIOSPORTING Magazine
PO Box 282, Pine Brook, NJ 07058, USA

VISA

124

morse code teaching tools
for the C-64 and 128

You control between-character timing for increased proficiency and greater speed

Suppose you've decided to learn a new language — French, for example. You could choose to study with a teacher in a classroom or on your own, using cassette tapes or records. In either case, you'd notice that the instructor would begin by pronouncing each word normally at the appropriate speed, but would lengthen the pauses between the words or syllables to give students time to recognize individual sounds.

Let's assume you've opted to learn French from records or tapes. What would happen if, instead of playing them at their proper speed, you played them at a slower speed? You'd probably have great difficulty recognizing any words at all.

Learning Morse Code is like learning a new language, and listening to code at five wpm is just like listening to language records or tapes played at the wrong speed.

At five wpm it's easy to fall into the trap of counting dots and dashes. Most people can't reach 13 wpm this way, so when they switch to learning to hear the rhythm patterns (i.e, *sounds*— Ed.) instead of individual dots and dashes, they're essentially learning a new code.

Unfortunately, this experience is often accompanied by a discouraging loss of speed, just when they need encouragement to upgrade. Too many would-be Generals give up at the Technician level because of the difficulty of breaking the dot and dash counting habit to relearn code at 13 words per minute.

The fastest way to a General Class license is to start at 13 wpm, with generous pauses between characters for an overall speed of five words per minute. This way, you'll learn code characters by recognizing rhythm patterns rather than by counting dots and dashes. Once you've learned to recognize the patterns, all you have to do is concentrate on reducing your reaction time. Just as on the language records, you'll find the time between the characters helpful for recognizing them and writing them down.

To skeptics who insist that they can't learn code, I like to introduce the letters V and B. I simply suggest that they think of the V as the Roman numeral $\overline{V}$. I ask them to recall Beethoven's Fifth Symphony, noting that the sound of the Morse V sounds just like the opening phrase: *di-di-di-dah*. For the Morse letter B (as in "Beethoven"), you just play it backwards: *dah-di-di-dit*. After a short demonstration, they can pick these letters out of small code groups, even though they may have to pause to figure out how many dots and dashes are used for each letter. This trick often provides the confidence they need to continue studying code.

code practice from the computer

When I started preparing for the Extra Class code test, I wasn't sure whether I was really improving my copying or merely remembering the material on the recordings. I bought one of those code practice keyers that generates random code, with an adjustable delay between characters. But without a printout of answers against which I could check my work, I was still unsure of my progress. When I finally got around to looking at computers, I was surprised to find how difficult it is to find a code program that includes the continuously variable spacing my keyer provides. Most programs offer only the choice of standard spacing or standard spacing plus one full space. This is too big a jump; a better method would allow for gradual reduction of the length of the pauses between characters, with character speed remaining constant.

Hearing of my problem, a friend offered me the use of his Commodore 64 computer and challenged me to write a code program that provides the variable spacing I believe is essential for learning the code. *Morse Code Teaching Tools*, the result of that effort, allows you to set the character speed and overall word speed to any logical combination of speeds between five and 50 wpm. It also performs the following functions:

- **Random practice.** Choose letters, numbers, punc-

By Dennis L. Green, KB8CS, 20039 Murray Hill, Detroit, Michigan 48235

tuation, mixed letters and numbers, or all characters. Select groups of one to nine characters or random lengths.

• **Keyboard Mode**. Send the characters as you type them on the screen. You can type up to 920 characters ahead; the character being sent will be highlighted with a brighter color.

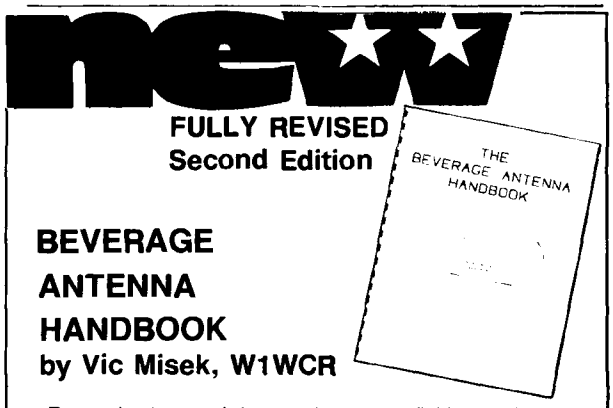
• **Message Entry**. Enter your own text, such as a sample code test.

• **Disk Access**. Format a new disk, save the current message, load a message, delete messages, or validate a disk.

• **Sending**. Send the current message or send random practice. Pause, resume sending, or return to the menu at any time. Select a blank screen or print each character on the screen after it's sent.

• **Printing**. Print the current message or random practice answers on the screen or printer.

The program is menu-driven to make it easy to use with minimal knowledge of the computer. Out-of-range or blank entries are ignored, and you're sent back to the menu. Most disk errors — such as bad file names or no disk in the drive — won't crash the program. For those who prefer single-key operations, the CRSR-right key will move the selection highlighted on the menu, but will work normally when you select a message from the disk directory. This program will run on the Commodore 128 computer in the "64" mode.



getting the timing right

The program timing is based on words of five characters and one space, for a total of 50 time elements. Dots and the time between dots and dashes are each one time element in length. Dashes and the time between characters are three elements long. A space character has the same timing as a silent "e" in a spoken word — that is, one element without the sound plus the usual three elements of time between characters. The word "PARIS" fits this description. When you set the word speed slower than the character speed, the three time elements between characters are lengthened.If you try a speed test, remember to put two spaces before the last word instead of the trailing space, since it's rather difficult to hear when a "space" has ended.

After filling my trash can with a number of early versions of this program, I discovered why it's so hard to generate accurate code on the Commodore 64 computer. A signal from the Complex Interface Adapter (CIA) chip's timer causes the computer to stop whatever it's doing sixty times per second to run a built-in machine language program that updates the clock registers and scans the keyboard and stores the value of any depressed key in memory. These interruptions in the execution of the program make the code inaccurate (and sloppy sounding) if a program loop is used to control the code timing. Using the clock registers in a loop to control the code timing won't work any better because they're updated too infrequently and the keyboard routine must finish before the BASIC program resumes execution and can respond to the change in the clock register.

To generate accurate code, it's necessary to use the CIA chip's timer interrupts to control the sound chip and give it priority over the keyboard and clock functions. The effect on the keyboard response shouldn't be noticeable to the average typist, and the clock isn't used by this program. The modified interrupt handler machine language is POKEd in from DATA written in BASIC to avoid the need for an assembler to enter the program. If you're familiar with machine language, you may wish to use the data to create a binary file, which will load faster.

how to get a copy of the program

Because of its considerable length (7 pages, 315 lines of coding) the program listing cannot be reproduced here; a free printout is available from *ham radio* for a No. 10 SASE with two units of first-class postage. If you'd like to have a ready-to-use copy of the program on a disk, send a certified check or money order for $8.00 to Robert A. Evans, N8GFE, 23540 Manistee, Oak Park, Michigan 48237.

ham radio

build a QSO "beeper"

End-of-transmission tone becoming more common

As an Amateur, you're no doubt familiar with the courtesy tones heard over repeaters, indicating the end of each transmission. You may have also heard end-of-transmission tones in SSB communications during contesting or poor conditions. This article describes several different circuits for producing these tones, along with some discussion of how they operate. I like to refer to these circuits as "QSO Beepers."

operation timing

The Beeper (**fig. 1**) transmits one or more short tone bursts after you're finished talking. This indicates to other stations that your station has finished transmitting and is now in the receive mode.

In many radios the PTT line from the microphone immediately unkeys the transmitter when you're through talking. However, if this were allowed to happen with a QSO Beeper in place, these trailing courtesy tones would be cut off. Therefore, after you unkey, the Beeper keeps the PTT line keyed (active) for the short interval of burst tone activity (see **fig. 1**).

The interval WAIT1 provides a delay-before-burst or "DBB" period. Without this short interval, the following beep tone (BEEP1) would "ride" the audio of the quick-fingered operator who unkeys instantaneously after talking. A duration of 0.1 seconds usually works well, but isn't critical.

BEEP1 is the desired tone burst, usually around 1 kHz and about 0.1 second or so in length. The pitch and duration are selected to provide a comfortable sound.

The other DBB intervals (WAIT2, etc.) provide the same spacing effect as WAIT1. The next desired tone bursts — designated BEEP2, etc. — have characteristics similar to the first.

Simple circuits can be used to produce these DBB intervals and the tone bursts. A single-burst Beeper cascades the DBB and burst generators. A multiburst Beeper can be made by cascading several single-burst Beepers. When the burst tones are set to different pitches (BEEP1, BEEP2, etc.), a melody distinctive to each station can be produced.

Figure 2 illustrates the general circuit of the Beeper. The Beeper is connected between the microphone output plug and the microphone input jack to the radio. Audio from the microphone connects directly through the Beeper to the radio. The Beeper's courtesy tones are injected into this line at the proper time.

A level transition detector senses when the PTT line from the microphone changes state as you unkey at the end of a transmission. This transition triggers the time interval generator to produce a pulse of fixed duration. This gating pulse in turn gates both the PTT electronic switch (controlling the radio) and the audio oscillator, producing the tone burst.

Since many PTT microphones operate by grounding a control line normally "pulled high," the circuits described here "pull" the radio PTT line to ground during transmit (see **fig. 1**). This can be achieved with an open-collector NPN transistor placed in conduction at the proper time. For improved circuit operation, a very low-resistance VMOS (TMOS, etc.) FET could be used in place of the bipolar device.

An extra line from the radio (via the microphone

By Richard L. Erhardt, KF6CU, 2200 Agnew Road #309, Santa Clara, California 95054-1502

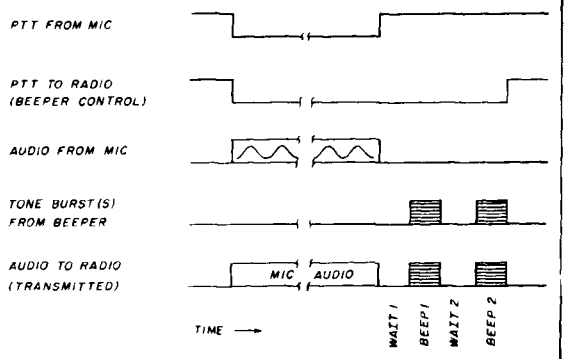


fig. 1. General beeper timing diagram.

defining the gate's digital state. The output of the gate follows this input spike with a pulse of width directly proportional to the resistor and capacitor values. Values of $R_p = 470$ k and $C_p = 0.22\mu F$ provide a pulse of about 0.1 seconds, yielding an effective delay-before-burst interval. (Triggering on the negative-to-positive transition instead can be accomplished by connecting the resistor to ground instead of the positive supply line. Note that the output in this case is also the inverse of the previous case, providing a negative-going pulse.)

audio oscillator

Figure 4 shows one way of implementing the tone

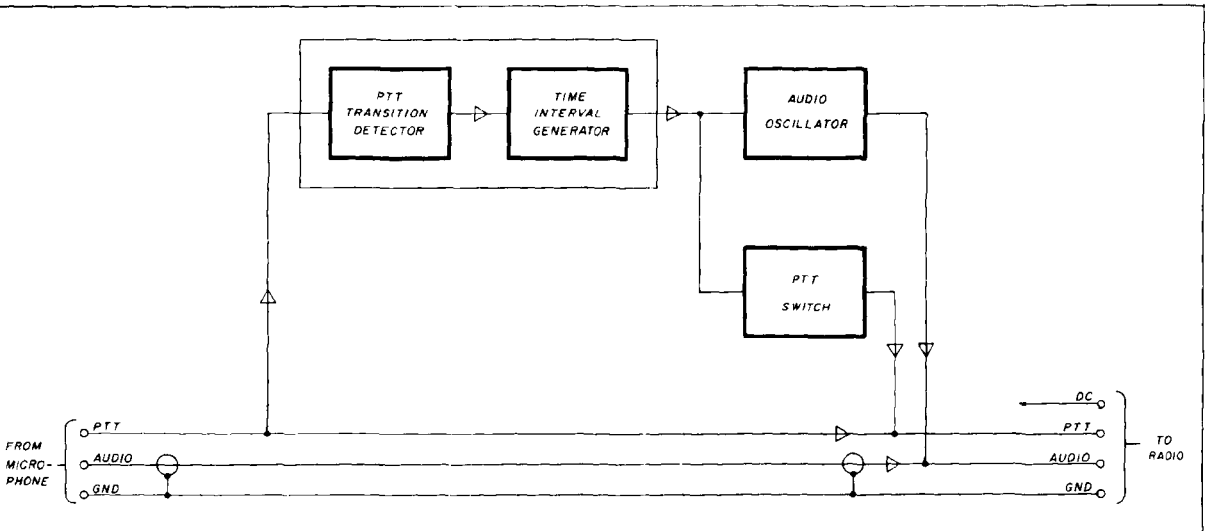


fig. 2. General beeper block diagram.

cable, for example) or an internal battery can supply dc input power. The use of CMOS circuitry keeps the dc input power requirement low, allows wide supply-voltage operation (+3 to +18 dc), and provides high noise immunity. The high input impedance of the CMOS gates allows realizable component values to be used in generating the desired time constants. Low power consumption and small size make the Beeper perfect for QRP outings (such as Field Day), net operation, and contesting.

time delay circuit

Figure 3 illustrates one way of implementing the time interval (pulse) generator, which is also referred to as a monostable multivibrator or "one-shot." Upon a positive-to-negative edge transition capacitor C_p produces a single spike at the input of the gate, charging through resistor R_p. This spike causes the gate input voltage to momentarily cross the threshold level

burst circuit, also referred to as a gated astable oscillator. Upon application of the burst-control signal, the gate is enabled and the output changes state. Resistor R_o feeds this output signal back to the gate input and capacitor C_o. As C_o discharges, the gate input voltage crosses the threshold level defining the gate's state and the output follows this input change. This out-of-phase feedback mechanism causes C_o to charge and discharge at a determinable rate, with the gate input voltage rising and falling accordingly. An output oscillation will be produced at a rate inversely proportional to the values of R_o and C_o. Notice that the tone burst has the same duration as the input burst-control signal because the gate is active only during this time.

Values of $R_o = 10$ k and $C_o = 0.1\mu F$ provide a frequency of about 1 kHz, producing a pleasing beep tone. A low-pass filter composed of R_f and C_f remove the high-frequency components of the gate's square

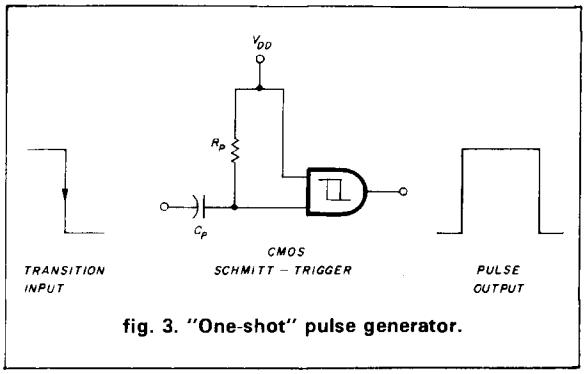


fig. 3. "One-shot" pulse generator.

single-tone QSO beeper

The circuit shown in fig. 5 illustrates a Beeper that produces a single beep. The first section, U1A, makes the necessary waveform inversion of the PTT negative-to-positive transition to that of positive-to-negative required by the "one-shots" (as in fig. 1 and fig. 3). R1 provides the necessary voltage pull-up for the microphone PTT switch that connects to ground when keyed.

Two "one-shots" have been cascaded to provide the necessary time delays. The first interval at U1B (by C1 and R3) is the DBB interval described previously. The second interval of U1C (by C2 and R4) sets the length of the beep tone. The resistor and capacitor values shown provide about 0.1 seconds of delay through each one-shot stage.

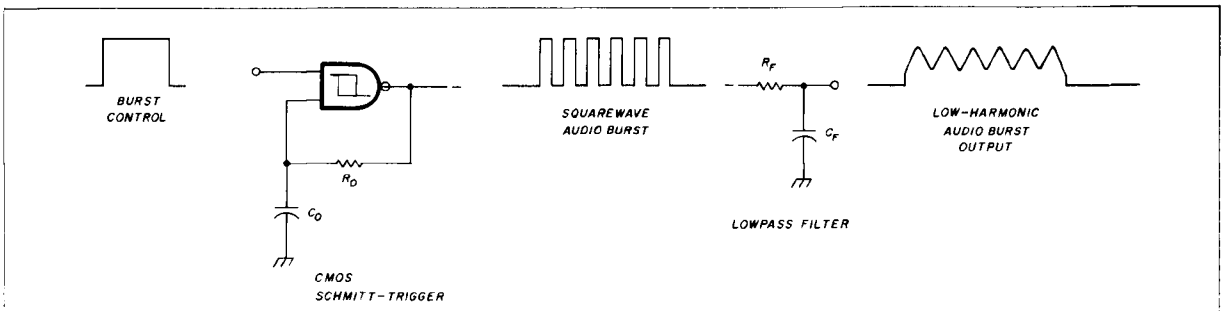


fig. 4. Gated-NAND audio-burst generator.

wave, leaving a lower-harmonic sawtooth-type waveform.

potentiometer or fixed resistor?

Both the monostable and astable circuits could use a potentiometer in place of the fixed resistor to allow flexibility in setting the interval or pitch. However, these two parameters usually don't have to be changed after the initial setting, so a fixed component works well. Potentiometers usually need more real estate than small fixed resistors anyway!

In both the one-shot and oscillator circuits the very high input impedance of the CMOS gate provides minimal loading of the RC circuit, meaning the time constant is effectively only a function of (realizable) values for the resistor and capacitor. At much shorter timing intervals, or higher oscillation frequencies, the input capacitance of the CMOS gate must be taken into account. At longer intervals (or lower frequencies) capacitor leakage must be considered. The Schmitt trigger hysteresis and the CMOS gate transfer function are also important for proper operation.

Keep these effects in mind when modifying or adapting either the one-shot or tone burst generators. More information about monostable and astable generators can be found in various application notes on CMOS gates such as the 4093 or 74C132 Schmitt-trigger NAND gate IC, or the 4069 Schmitt-trigger inverter IC.

The output of U1C controls or gates the audio oscillator of U1D (set by C3 and R7), yielding the output tone burst. Low-pass filtering is provided by R8 and C4. Potentiometer R9 allows the amplitude of the tone burst to be set. Capacitor C5 simply blocks dc between U1D and the audio line; many active microphones receive dc power from the radio via this line, which must not be interfered with by the dc present at the potentiometer output.

Transmitter keying (PTT) is provided by the open-collector NPN transistor, which is turned on during both one-shot intervals by "wired OR-ing" through diodes CR2 and CR3. U1A is also ORed via CR1 to key the radio PTT line while the operator is keying the microphone. Without CR1 the radio PTT line would be active only during the DBB and tone burst periods via CR2 and CR3 (fig. 1). As previously mentioned, a very low-resistance FET could be used at Q1 in place of the bipolar device for improved performance. The collector current and open circuit voltage present on the radio PTT line must be considered when selecting Q1. Most solid-state rigs with PTT keying via the microphone operate this control line with relatively low voltage and current that are easily handled by the 2N2222 or its equivalent.

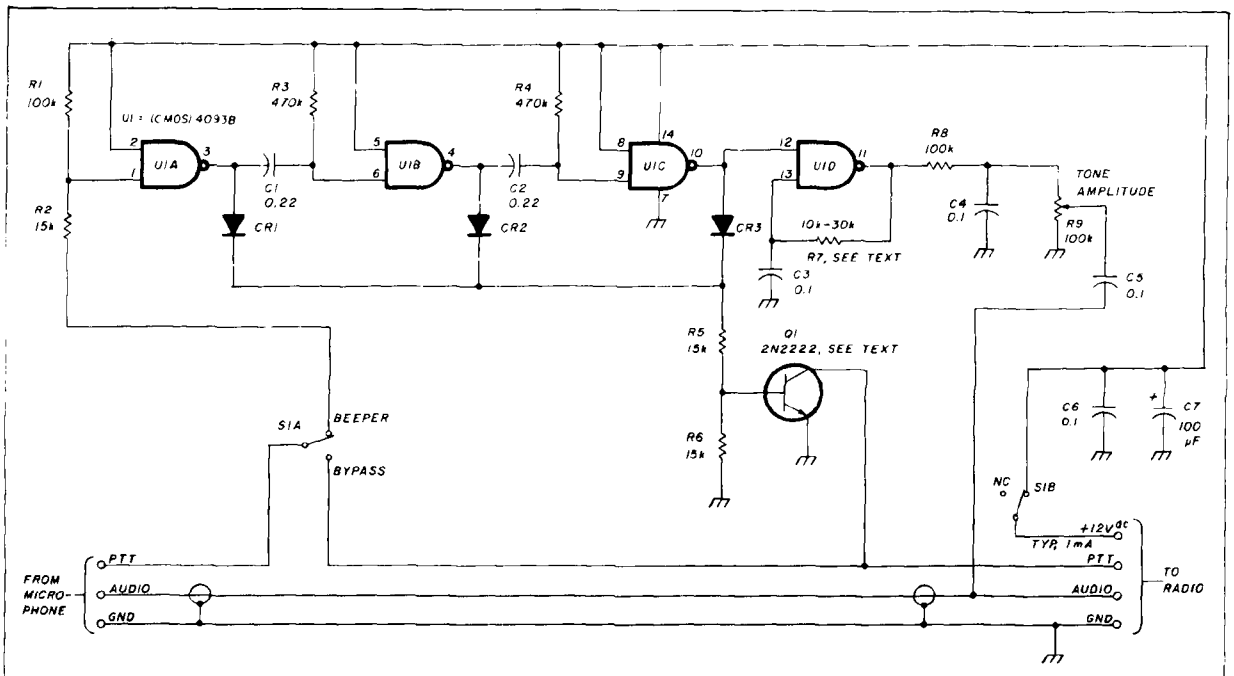


fig. 5. Single-tone beeper schematic and parts list.

Single-tone Beeper parts list

C1,2	*0.22µF, 50 volts*	*nonpolarized, low-leakage*	*(RS 272-1070)*
C3,4,5,6	*0.1µF, 50 volts*	*nonpolarized, film*	*(RS 272-1069)*
C7	*100µF, 35 volts*	*electrolytic (or tantalum)*	*(RS 272-1028)*
CR1,2,3	*1N914*	*general signal diode*	*(RS 276-1620)*
Q1	*2N2222A*	*general purpose NPN*	*(RS 276-1617)*
R1,8	*100 k*	*1/4 watt*	*(RS 271-1347)*
R2,5,6	*15 k*	*1/4 watt*	*(RS 271-1337)*
R3,4	*470 k*	*1/4 watt*	*(RS 271-1354)*
R7	*10-30 k*	*1/4 watt (set for tone pitch)*	*(RS 271-13xx)*
R9	*100 k*	*potentiometer*	*(RS 271-338)*
S1	*DPDT*	*toggle (or slide)*	*(RS 275-663)*
			(RS 276-1999)
socket	*14-pin DIP*		*(RS 276-168)*
U1	*CD4093B*	*CMOS quad NAND Schmitt (74C132)*	

perfboard with solder pads, 0.1-inch centers

DPDT switch S1 allows the Beeper to be switched in or out of the circuit as desired. Note that in the "bypass" mode, dc power to the Beeper doesn't have to be applied for the radio to be keyed by the microphone; thus, normal radio operation is restored. The base-to-ground resistor at Q1 ensures that Q1 won't conduct while the Beeper is in the bypass mode.

a dual-tone QSO beeper

The circuit shown in **fig. 6** describes a Beeper that produces either a single tone or two tones in sequence. Here the single-tone Beeper described above is cascaded for sequential operation. For simplicity, a single panel switch is used to select either the bypass mode, or the one- or two-beep mode. However, two tradeoffs must be made in the bypass mode when using only the single switch: first, dc power to the Beeper is always connected, which will probably not pose a power consumption problem; and second, input to the Beeper is always connected (even though it will be

functionally inhibited). More on this second tradeoff follows.

As in the single Beeper, U1A provides the necessary signal inversion of the PTT line, with R1 providing the pull-up function. Notice here that when switch S1 is in the bypass mode, the input via R2 is still connected to the radio. If the radio uses a relatively high voltage for the PTT "pull-up," the IC can be damaged if this voltage exceeds the IC supply voltage. Optional diode CR6 limits the input voltage at U1A from exceeding the supply voltage, with resistor R2 providing current limiting. Alternatively, a zener diode of appropriate value could be used between the input of U1A and ground. In rigs where the PTT pull-up voltage is the same or less than the Beeper supply voltage, no problem should exist, so CR6 can be omitted. U1B sets the first DBB period (by C1 and R3) and U1C provides the necessary gating (by C2 and R4) for the first tone burst oscillator U1D. U2B sets the second DBB period (C3 and R5) and U2C (with C4 and R6) gates the second tone burst oscillator U2D. Gate U2A diplexes the tone burst signals from U1D and U2D and buffers them for output to the low-pass filter of R11 and C7 and level setting potentiometer R12. The radio PTT line must remain active throughout the intervals (WAIT1 + BEEP1 + WAIT2 + BEEP2 + ...). This is achieved by OR-ing the control gating lines together. As with the single Beeper, PTT operation is provided by the open-collector NPN transistor, which is held active during all one-shot intervals by "wired-ORing" through diodes CR1 through CR5. Again, CR1 is required to key the radio while the microphone PTT line is activated by the operator (see **fig. 1**).

The DPDT-center-off switch allows selection of single or dual beeps, or of bypassing the unit. In the dual-beep mode, all the "one-shots" are cascaded. Notice that in the single-beep mode, U2B is inhibited by tying the input to the supply line. This allows only the first DBB period and the first tone burst to be transmitted. The radio PTT line is immediately unkeyed after this first tone burst.

Two switches could be implemented to disconnect dc input power and the Beeper input while in the bypass mode. Switch section S1B of **fig. 6** could still be used, while a DPDT switch identical to S1 (A and B) in the single Beeper of **fig. 5** could be added. This would alleviate the problems of the single DPDT-center-off switch previously discussed. A DIP header with 1/8-watt resistors that plugs into an IC socket can be used for the interval- and pitch-setting resistors of R3, 4, 5, 6, 9, and 10. This allows flexibility for changing values later, but doesn't take up as much room as potentiometers.

a multi-tone QSO beeper

It's also possible to make a Beeper capable of

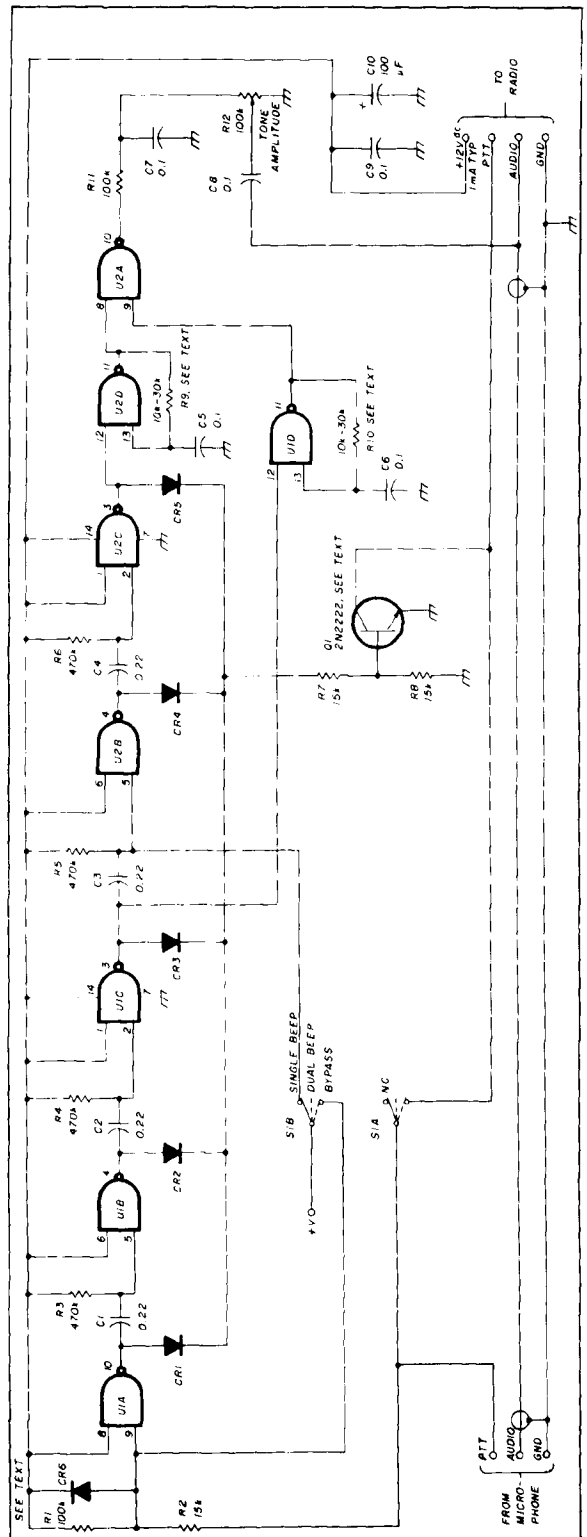


fig. 6. Dual-tone beeper schematic and parts list.

Dual-tone Beeper parts list:

C1,2,3,4	*0.22μF, 50 volts*	*nonpolarized, low leakage*	*(RS 272-1070)*
C5,6,7,8,9	*0.1μF, 50 volts*	*nonpolarized*	*(RS 272-1069)*
C10	*100μF, 35 volts*	*electrolytic (or tantalum)*	*(RS 272-1028)*
CR1,2,3,4, 5, and CR6 (if used)	*1N914*	*general signal diode*	*(RS 276-1620)*
Q1	*2N2222A*	*general pupose NPN*	*(RS 276-1617)*
R1,11	*100 k*	*1/4 watt*	*(RS 271-1347)*
R2,7,8	*15 k*	*1/4 watt*	*(RS 271-1337)*
R3,4,5,6	*470 k*	*1/4 watt*	*(RS 271-1354)*
R9,10	*10-30 k*	*1/4 watt (set for tone pitch)*	*(RS 271-13xx)*
R12	*100 k*	*potentiometer*	*(RS 271-338)*
S1	*DPDT center-off toggle or slide*		*(RS 275-664)*
sockets	*14-pin DIP*		*(RS 276-1999)*
U1,2	*CD4093B*	*CMOS quad NAND Schmitt (74C132)*	
perfboard with solder pads, 0.1-inch centers			*(RS 276-168)*

producing many tones in sequence. The one-shot intervals could conceivably be cascaded indefinitely, producing many DBB and burst intervals. However, component count would increase accordingly.

A less complex circuit — operating on a slightly different principle than that previously described — could be produced. The end-of-transmission on the microphone PTT line could still be detected as a state transition. However, instead of using discrete time interval "one-shots," a clock (gated astable circuit) and a serial shift-register could be used to create alternate intervals for DBB and burst gating. The various audio burst lines would be diplexed into a multi-input NAND gate, as in the dual Beeper. The shift-register outputs could be ORed to control the (NPN) PTT switch. The last register output desired should be fed back to disable the clock and reset (i.e., clear) the register.

Similarly a (gated astable) clock could drive a multibit binary (or BCD) counter chip (e.g., a 74C161). The counter's binary output could be decoded into many single lines by a demultiplexer chip (e.g., 74C154) to create the DBB and burst gating intervals. Again the astable burst outputs would be diplexed by a multi-input NAND gate.

Note that in both these methods the length of each interval cannot be different because each clock pulse has identical width. Also keep in mind that each additional beep tone increases the length of the transmission; the operator on the receiving end may not need to hear an entire melody to know that you've finished transmitting (some repeaters sport three courtesy tones, but these tones are wisely kept very brief).

alignment

Tune-up of the QSO Beeper's interval, tone pitch, and tone amplitude can be done with an oscilloscope; a two-channel scope works nicely. By monitoring the audio and PTT lines at the radio microphone port, the signals can be verified against those of **fig. 1**. Beeper amplitude is best set by relative comparison with the microphone audio level. (The microphone level may be reduced if the potentiometer is set at too low an impedance.)

Checking the tone(s) can be done without continuously keying and unkeying the transmitter. While keying the radio with the microphone PTT switch, monitor the Beeper audio line to the radio. Flip the mode switch between the dual-beep (center) position and the bypass position. The Beeper will inject its tone(s) onto the audio line every time this is done, alleviating the need to switch from transmit to receive and back again just to produce the tone(s).

The true and final check should, of course, be on the air. Comments from a receiving station should be helpful. An auxiliary receiver also is very convenient for monitoring the QSO Beeper.

If you choose to modify the Beeper, avoid connecting the radio PTT line (and the PTT switch) directly to the input of the Beeper; a feedback loop would be set up when the radio PTT line is keyed (pulled low), preventing the negative-to-positive transition via the microphone PTT line.

I'm looking forward to hearing your Beeper during our next contest QSO.

ham radio

radio addiction: case history of an enthusiast

I recently bought a house in Tucson. *When I first confronted the real estate agent, I advised her of its necessary attributes: four bedrooms, two baths, a large lot, underground utilities, and no antenna restrictions. I chose northwest Tucson over the more scenic southern foothills, where the Catalina Mountains blocked the great circle route to my favorite radio target: Europe. Northwest Tucson has a nice clear horizon in that direction.*

That night, after signing away my life savings, I thought about the purchase. "My God," I thought to myself, "how much simpler life would be without this radio addiction!"

As the agent showed me the house, I imagined where the main tower would be placed, the orientation of the zepps, and how I could actually place a full-sized 160-meter dipole on the lot. Thoughts about how the rugs really didn't match my furniture, the amount of work required for redecorating, and the like, were secondary. It was obvious that a serious metamorphosis had transpired: I had finally asked — and answered — the question, "Why is Amateur Radio so important?"

The answers lie deep inside all of us. But this time I dared to quantify them, to analyze my own addiction's history — and then, in a moment of impudence, actually write everything down! Prejudice, bias, love, hate; all surfaced. But it really began long ago and far away . . . .

It was 1957 in South Chicago. I think it was my mother's hi-fi set that did it. The power amp didn't have a cabinet, so the transformers and tubes were naked to youth's curiosity. And what tubes they were! A 5U4 rectifier and those noble push-pull 6L6s. I was only six, but somehow I knew that the tubes were the components of consequence. Turn the switch on, and they made a crinkling sound as the red filaments lit up. As the rectifiers kicked in and the filter capacitors inhaled their charges, jumping blue lights danced around the glass envelopes. Music would then emerge from the speaker cabinet.

It was as if this curious assemblage were alive, waking up to perform its miraculous functions. If those had been the last tubes I'd ever seen, I'm sure I'd swear they were over a foot tall. First conclusion: *It's OK to like tubes.*

For six-year-olds, particularly those who grow up to be engineers, curiosity eventually leads to more direct involvement. (If observation is interesting, manipulation must be bliss!) I remember grabbing one of the 6L6s — I think it was the righthand one — and yelling out as the heat singed my inquisitiveness. The next thing I remember was my mother telling me, with great urgency and unusual directness, *never* to play with tubes, hi-fi's, or electricity again. "Wow," I decided, "this stuff must be better than I thought!"

My parents loved music. I inherited that affection, but with some twists: when I hear "The Blue Danube," for example, I don't conjure up images of a placid river scene reminiscent of the Hapsburg dynasty; I envision a pair of 6L6s!

I had to be content with just watching those tubes until we added another piece of equipment to the hi-fi: a radio tuner. By this time — age eight or nine, perhaps — I was actually operating the hi-fi, but under strict instructions not to "play" with it. I began DXing the a-m broadcast band. My mother asked me why I preferred to listen to fading noisy signals rather than clear, clean local stations. That was a good question. In retrospect, I've reached a second conclusion: *It's OK to listen to noise.*

A few years later I began reading radio books written for young people. The Chicago Heights Public Library had three. Then I read about Amateur Radio and found that these guys didn't just listen, they transmitted — even farther than WLS!

One night as I was listening to Petula Clark sing "Downtown" on the old 6L6s, I heard "CQ CQ CQ 40 THIS IS W8MAE PORTABLE 9 OVER." A few days later I found out that it was a guy down the street who had just moved in. I rang his doorbell and told him I could hear him on my hi-fi.

"Well then," he said, "I'll stop transmitting."

"No!" I said, "I've read about Amateur Radio and I'm very interested in it!"

He invited me down into his basement. I'll never forget that station: an SX-25, Viking II, with matching matchbox and a myriad of accessories, all on an old

By Robert J. Zavrel Jr., W7SX, P.O. Box 23447, Tucson, Arizona 85734

beat-up wooden desk. A partially rusted Ohio license plate — W8MAE — hung on the wall. QSL cards were strewn about, and there were tubes everywhere — on the desk (these were the important ones) and in boxes on the floor. There was even a "dead" one hanging from a noose strung from a nail in the wall.

Marty was the first guy to tell me he liked tubes. "So do I," I said. He turned up the volume on the SX-25. 40 meters was filled with a-m signals. We heard a CQ, and he responded. A switch was thrown, the receiver went mute, a red light came on, and we were on the air. The room lights that were on dimmed, and those that were off came on. This, of course, was precisely the type of electrical chaos that appealed to southside juveniles!

Marty was bald. He was dressed in his work clothes: soiled green coveralls. A steelworker, he'd been transferred from Cleveland to Chicago Heights. This coarse-looking character, this man of blast furnaces and hot rolls, threw that switch — and with all the eloquence and reverence of a Shakespearean master, clutched the D-104 microphone and made the QSO. Meters moved, lights dimmed, and high-modulating iron vibrated to this rich, deep Midwestern voice, a voice heard across the continent. I was spellbound with the magic of radio.

With an Elmer only three doors down, I got my Novice license (WN9RAT) within a year. Soon I was putting up antennas and trying to work DX.

Back then, Novices could run 75 watts input. The transmitter had to be crystal controlled. Crystals cost $3 each, a goodly sum for 14-year-olds in 1965; spending all I had on radios, I was always broke.

My friends, who thought I was weird, were the first to ask the recurring question, "What do you talk about on the air, anyway?"

"Signal report, name, location," I replied, "and then anything that I think of."

"Sounds *boring*," *they said.*

Remarks like these always left me feeling disappointed, as if I'd somehow failed to convey my enthusiasm effectively. Examining this disappointment years later, I thought about other hobbies. What good is a pilot's license, for example, if no passengers or cargo are transported? The pilot flies from Point A to Point A. How silly! Obviously, if you have to ask the question, you've missed the point. Just as pleasure flying is flying for the sake of flying, Amateur Radio operation is operating a radio for the pleasure of operating a radio. It doesn't have to be more, it doesn't have to be practical, because it's the practice of an art. My third conclusion, then, is that it's not what you say, but how you say it — and *Amateur Radio is a very subtle way of saying who and what you are.*

Then there was Tri-Town, our local radio club — a whole room full of guys who liked tubes. (Some of the guys even liked transistors, but they were just too weird for me.) Most of the guys liked 2 meters and were talking about repeaters. Their single-channel 2-meter rigs were big . . . bigger, even, than my NC-300. The rigs had plenty of tubes inside them, and the tubes had something to do with "limiting," though I didn't know what that meant. My dismay peaked when I heard how much DX could be worked with these rigs; it seemed like an awful lot of tubes for just talking across town. I remember thinking that "limiting" meant "limited DX." Looking back on that experience, I came to my fourth conclusion: *It's OK not to get excited about fm.*

Ted, K9YOE, was a member of the club. A DXer, he lived at home while attending college. He had an NC-300, a Ranger, and a three-element tri-band quad atop his parents' roof. Ted was — and is — the finest operator in my recollection. His ears had the precision of a 10,000-point, real-time Fast Fourier Transform processor. With his 60-watt output, he managed nearly 300 countries confirmed, all on CW and a-m.

QST includes transmitter power class in their listings of ARRL DX Contest results. In 1967 or 1968, the top three in Illinois were "Class C" kilowatts; Ted placed fourth with a "Class A" 60 watts, followed by any number of high-power entrants. Ted was "cool"; even my sister, who thought all my friends were nerds, asked who he was after he came over to visit. My fifth conclusion? *You can be a ham and still be "cool."*

Another member of Tri-Town was Oak, a friend of Ted's. Now W9RX, Oak had a massive station in his basement built into a large homemade cabinet. In his back yard, there was situated a 120-foot tower with a TH6DXX on top and a prop pitch motor at the base. A full-sized 40-meter dipole was attached to the boom of the TH6DXX, and a sloping dipole for 80 rounded off this five-band monster. Oak taught me an important lesson: *It's OK to be extravagant with hardware.*

Most addicts end up pushing the stuff they need, eking out a living and subsidizing their habits in the process. Amateurs are no exception — in fact, they're licensed by the authorities, with special spectral places set aside for their habitual indulgences.

My case is typical. Mom warned me about the habit, and then Marty, a casual user, turned me on. My need for DX led to harder stuff; I wanted higher and higher antennas. I went to work in radio broadcasting. Finally, I graduated to the Big Leagues with a degree in Physics. Now, through my work, *I'm an international* dealer.

Sometimes the question arises, "Do you want to kick the habit? Go straight? Drink beer with the guys at the local bar every night and watch football on TV?" My seventh conclusion: *No way!*

ham radio

the technology of commercial television part 2: hardware

Our ham's-eye tour continues — with a close-up look at the technology

In part 1 of this article I described the evolution of and standards for TV signals. In this installment, I'll describe how these signals are actually generated.

If you were to walk into a typical TV control room (and I'd suggest that you do), you'd find a dark inner sanctum glowing with the light of TV monitors and green oscilloscopes. You'd also be greeted with several — possibly several *dozen* — equipment racks loaded with apparently unidentifiable equipment, which is in fact, likely to consist of sync-related devices.

Although the actual sync generator is really rather small, every piece of video equipment must be timed with, or "locked into" it. If the sync generator is the heart of a TV station, the sync distribution system is the arteries and capillaries. Each branch of the arterial system is called a DA, or distribution amplifier. **Figure 1** shows a typical sync DA system. As you can see, this scheme allows any number of sources to be driven. In preparing **fig. 1**, I stopped drawing at 16 video sources; I could have easily gone to 64 sources with just one more generation of DAs.

These video sources can be just about anything including cameras, VCRs, electronic digital effects, film chains, or test signal generators. Regardless of what they are, station sync must be fed to all of them. Obviously, the sync generator is critical to the system; if it dies, you go off the air. If you go off the air, you lose money. If you lose money, you lose. And if you lose, you wish you had a spare sync generator. Consequently, most stations have a spare sync generator ready to go on line at a moment's notice.

If you didn't read part 1 of this article, this part may make little sense. If you did read part 1, you already know all about the sync signal and why it's so important in TV. You may recall that I omitted satellite receivers from the list of possible video sources at the conclusion of part 1; this is because it's difficult to plug your DA into a satellite and lock it up to your TV station. So what do we do if we want to use a satellite image in our TV station without recording it? We lock our sync generator to the satellite instead. This technique is known as "gen-lock" in TV circles. A station that's gen-locked to a satellite will exhibit extreme stability and frequency accuracy. All satellite uplinks are already gen-locked to atomic clocks, so if you're in turn locked onto the satellite, you'll have atomic accuracy, too. We can gen-lock a station to satellite sync even if we don't want to use the video programming from that satellite; in this case, we're really using the "bird" as a cosmic timer.

how it works

So, how does a sync generator work? Actually, the generator is nothing more than a digital clock with a few steps added. All begin with a 3.58-MHz crystal oscillator. This oscillator is useful in certain studio equipment needing a subcarrier (SC) input. Although the example shown in **fig. 2** is now usually built on a single IC, it's important to understand its function.

The 3.579545 signal, being a wave, isn't of a suitable shape for the subsequent digital dividers. So it first goes through a comparator, which is a device used to convert sine waves to square waves. (Back in the old days we would have used a Schmitt trig-

By Eric Nichols, KL7AJ, Box 0, North Pole, Alaska 99705

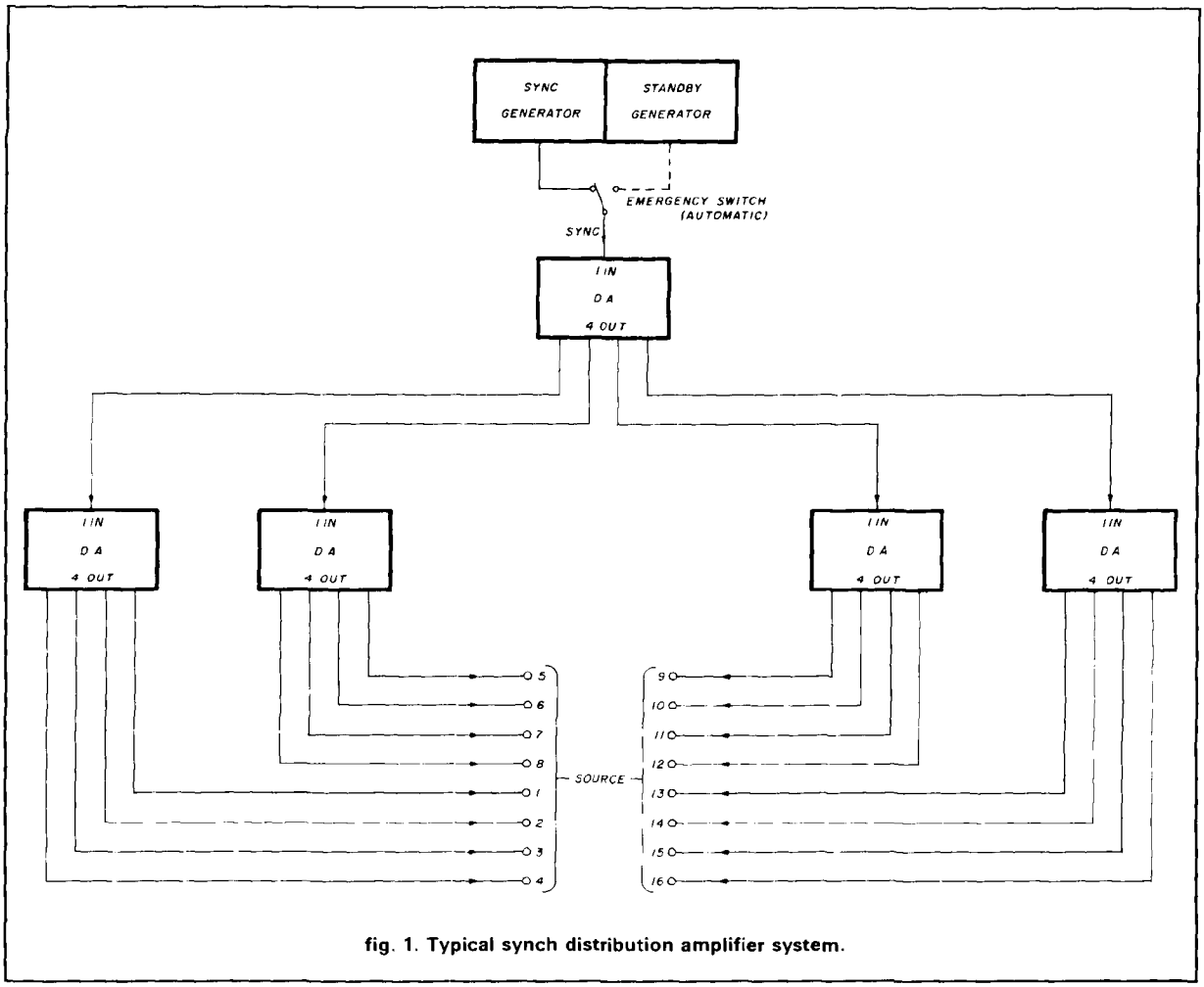


fig. 1. Typical synch distribution amplifier system.

ger, the electronic equivalent of a toggle switch, to do the job.) Now that we have nice square waves, we can use them to drive our digital dividers and multipliers. (As an *extra* credit project for you digital folks, try to figure out how to divide by 455 using JK flip-flops. That should keep you going for a while!)

A careful look at **fig. 2** will reveal that all the important frequency relationships necessary for TV are right there. And you can see that the relationships allow for quite a simple circuit, logically speaking. Remember, this was all developed before microprocessors or even transistors were available! Certain experimental HDTV systems rely on the ability to shift these numerical relationships at will, which is an easy job with microchips. But we'll skip that discussion because this article deals with NTSC (see part 1, December 1987, page 57).

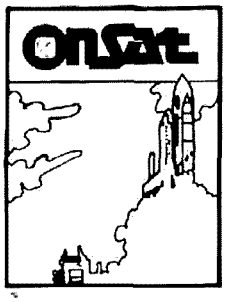
transmission line review

Before I can discuss sync distribution further, I need to talk about transmission line theory. (This may be painful for some of you, but this subject is essential). A transmission line is a device for carrying signals from a generator to a load. These signals can be video, audio, sync pulses, or subcarriers. In NTSC television, the transmission lines for video and sync pulses are coaxial cables with a characteristic impedance of 75 ohms. The characteristic impedance of a coaxial transmission line is a function of the ratio of the inside and outside conductor diameters. **Figure 3** shows the cross section of a high-impedance line and a low-impedance line. Notice that even though the outside diameters of each are the same, the impedances are different.

So, what does this all have to do with video transmission? Well, if video travelled through coax cable infinitely fast, there would be no significance. But electrical signals travel through cables at a finite speed, typically around 66 percent of the speed of light in free space. Because of this, we have the possibility of the signal being reflected from the receiving end of the line, if corrective measures are not taken to prevent

OnSat

"America's Weekly Guide to Satellite TV"



The best in satellite programming! Featuring: ★ Over 120 Channels listed ★ Weekly, Updated Listings ★ Magazine Format ★ Complete Alphabetical Movie Listings ★ Sports Specials ★ Prime Time Grids ★ Specials ★Programming Updates!

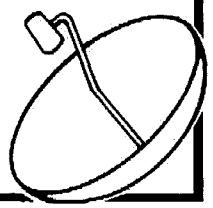
- **Only $45.00 per year (52 weekly issues)**
- **2 Years $79.00 (104 weekly issues)**
- **$1.00 for sample copy**

*NC Residents must add 5% Sales Tax

Subscribe Today!

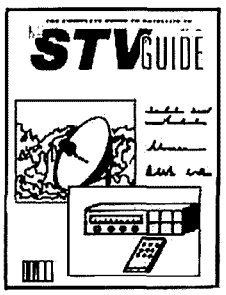
call toll free 1-800-234-0021
Visa® and MasterCard® accepted

OnSat PO Box 2347 Shelby, NC 28151-2347



STV GUIDE

The new **STV Guide** contains valuable information on zoning regulations, scrambling, plus technical tips for installing or updating a satellite system—and now a precise monthly guide to satellite TV with the latest program listings for over **90 channels**!



All this in each complete issue of **STV Guide**!

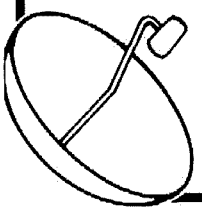
- **Only $48.00 per year (12 monthly issues)**
- **$2.00 for a sample copy**

*NC Residents must add 5% sales tax

Subscribe Today!

Call toll free 1-800-234-0021
Visa® and MasterCard® accepted

STV Guide PO Box 2384 Shelby, NC 28151-2384



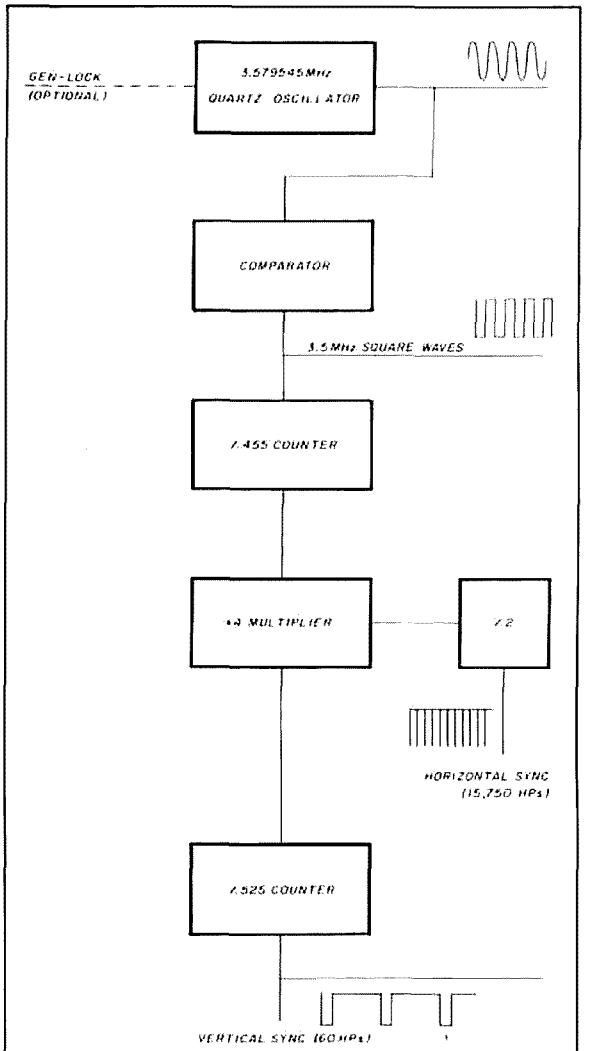


fig. 2. Sync generator block diagram.

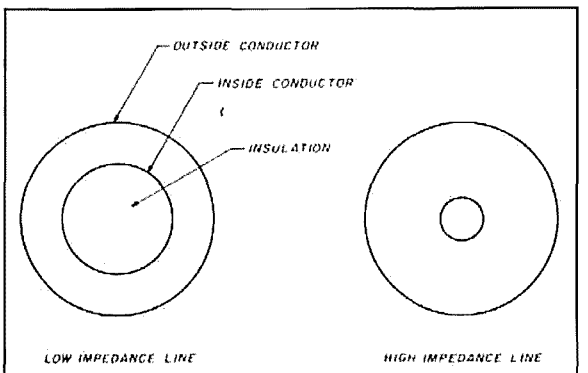


fig. 3. Low and high impedance transmission lines.

169

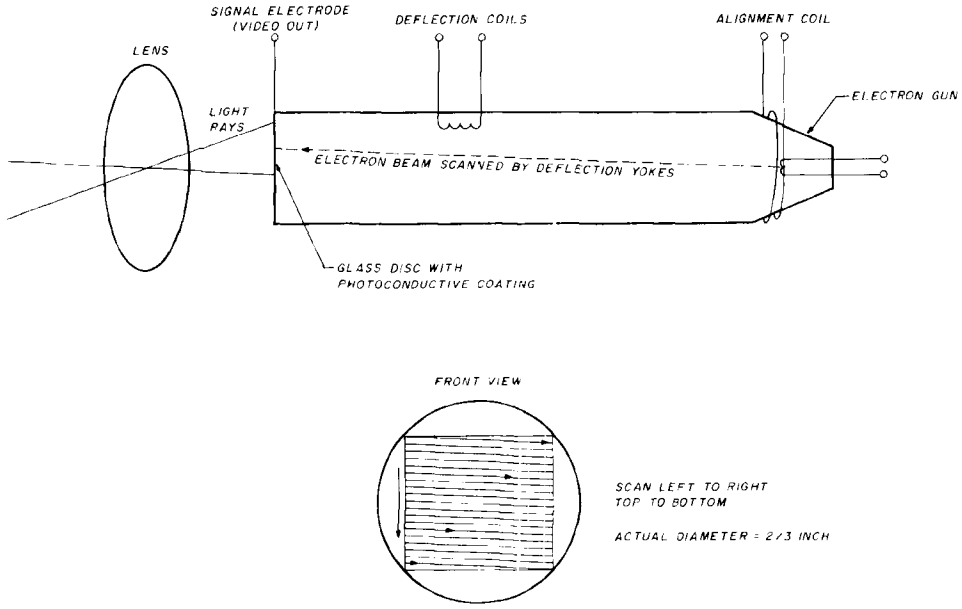


fig. 4. Vidicon diagram.

this. We prevent reflections by terminating the transmission line with a resistor equal to the characteristic impedance of the line. In video, we terminate the end of every coax cable with a precision 75-ohm resistor.

We could reverse the definition and say that the characteristic impedance of a transmission line is that which experiences no reflections when terminated with a known resistance. In other words, we can send a signal down a piece of transmission line which is unknown and change the value of terminating resistor until no reflections are experienced. Under these conditions we can then measure the value of our terminator, and then know that the characteristic impedance of our line is the same value. Fortunately we don't have to do all this in real TV, because we use only cables known to have a 75-ohm impedance, but we can still terminate a cable improperly by either using too many terminations or terminating the cable somewhere other than the end (non-terminal termination!)

What does an improperly terminated signal do? Depending on the nature of the original signal, reflections can manifest themselves in different ways. If the signal is continuous, such as an RF carrier, the signal reflected from the unterminated end recombines with the power going the "right" direction to form standing waves. These standing waves are voltage lumps and valleys which repeat at periodic intervals from the end of the cable. Also the input impedance will no longer be equal to the characteristic impedance of the line at every point on the line. Instead, we'll have a high SWR. If the generator is an RF transmitter, retuning of the "finals" may be necessary to deliver full power into the line. Also, under certain conditions, a high SWR may cause undue stress on marginal coax cable.

Video and sync signals, by their very nature, are not continuous, and therefore reflections do different things to these signals. Since pulses from sync generators are of very short duration, it's unlikely that a forward-going pulse and reflected sync pulse would ever overlap each other. So "standing waves," as most radio people know them, aren't the real problem. Instead, a sync pulse reflected from the end will be re-reflected from the sync genrator and will reappear at the load end in a more or less random time, depending on the length for the cable. This causes "ghosting" or double-syncing. Unfortunately, these ghosts can't be removed by reorienting the receivng antenna or twiddling the fine tuning knob on the receiver; instead these ghosts will be built into the transmitted signal!

The point of this is to say that it's a good idea to terminate the cables in a TV plant properly. But proper termination of the cables hasn't solved all our problems. You'd think that at 66 percent of the speed of light you wouldn't have to worry about the time it takes for a video signal to get from point A to point B in a studio. Unfortunately, nothing could be further from the truth. One of the big headaches in TV engi-

neering is trying to insure that all the video sources arrive at the switcher (more on switchers later) at the same time.

Small mis-timings usually result in tiny color phase (hue) shifts between sources. This can usually be corrected electronically at the receiving end. Longer mis-timings result in a visible left-right shift of the picture. The only way to correct this is to make sure that all the video cables are the same length. This, of course, means that every cable is as long as the longest cable, regardless of whether you need that much stretch or not. That is why the first thing most people ask when they see a control room is, "Why do you have all that extra cable lying around?" I'd love to cut all the cables to just the right length and neatly bundle them somewhere, but I've never seen a TV control room where it worked out that way. TV is one place where you first make it work, and then you try to make it pretty. When you finally do find a place to put all the cable, someone wants to add a new video source, and then you go through it all over again.

video sources

Now that we've temporarily exhausted the subject of coax cables, let's talk about video sources. The first and most basic video source is, of course, the camera. I could trace the history of camera tube development, but I'll stick with the most common type of "eyeball," the vidicon. (There are several varieties of vidicons known as saticons, plumbicons, and Ledicons, but these are only chemically different; the actual wiring is about the same.)

A vidicon is essentially a backwards TV picture tube. Instead of using an electron beam to control the emission of light, we use a property known as photoconductivity to control an electric current. The main difference is that the screen of a vidicon is very small and perfectly flat. The screen of the vidicon is coated with a photoconductive layer of antimony sulfide. If we were to focus a visual image on the surface, we would, of course, have light and dark areas. The light areas are highly conductive, while the dark areas are resistive. As in any other tube, an electron beam emitted from a hot filament is focused to a very thin beam with magnetic yokes (coils). This electron beam is scanned across the glass disk by magnetic yokes much as it is in a TV receiver. The vertical deflection yoke does the same thing at a 60-Hz field rate. When a beam hits a light spot, it flows out of the signal electrode with ease. When it hits a darker spot, less electron current flows out the signal electrode. This signal fluctuates in accordance with the scan and illumination of the vidicon surface. Obviously, the narrower the electron beam, the better the resolution of the vidicon. Keep in mind that a full-size raster must be concentrated on a vidicon with a 0.66 inch face diameter.

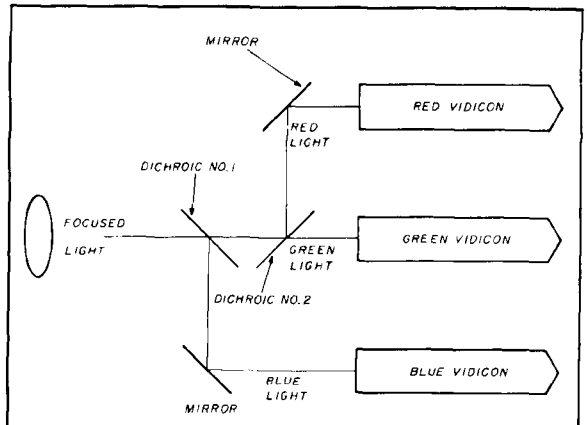


Fig. 5. Color separator.

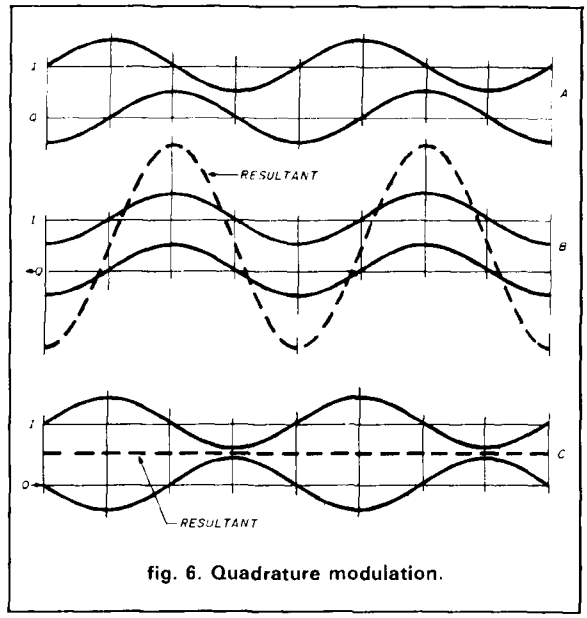


fig. 6. Quadrature modulation.

The output of a vidicon is extremely weak and is not linear (i.e., in direct proportion) to the light falling upon it. The weak signal is accommodated by using a low noise field effect transistor. (This used to be done with low-noise triode tubes such as those in the famous Nuvistor series.) This preamplified signal then goes into a gamma corrector. Gamma is the mathematical name for the non-linear voltage characteristics of a vidicon. A gamma corrector is just an amplifier that has an amplification characteristic that is equal but opposite to that of the vidicon. What we get out of our gamma-corrected preamplifier is a video signal of a voltage directly proportional to the light level. Without gamma correction, we have contrast that looks washed at medium gray levels — not very pleasant to watch.

the sync adder

Now all we have to do is take our video signal and add it to our station sync. The device that does this is called a sync adder; its product is called composite video, or video + sync. Most cameras have internal sync adders.

Now we can take our composite video signal and feed it to a monitor by means of a properly terminated 75-ohm coaxial cable transmission line. Voila! A picture appears.

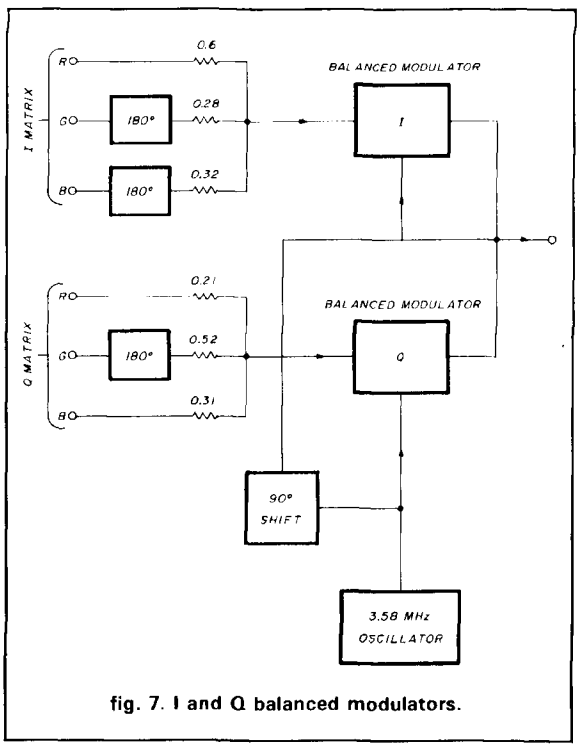


fig. 7. I and Q balanced modulators.

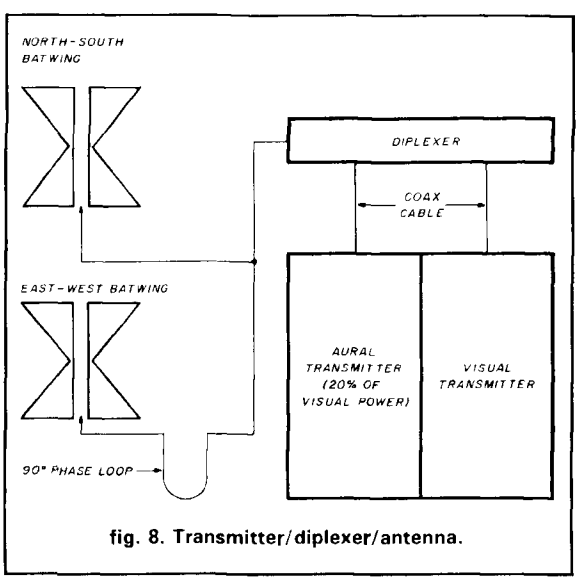


fig. 8. Transmitter/diplexer/antenna.

it's all done with mirrors

If we want a color picture, we just have to do the above three times; once for red, once for blue, and once for green. **Figure 5** shows a color separator for a three-gun color camera. As you can see, it's all done with mirrors. There's actually no difference in the actual vidicons; the only difference is in the color light that's fed to them. A vidicon doesn't know anything about the color of light hitting it. It simply knows how much is there. You can't tell blue video from red video from green video, either.

A dichroic is a mirror that transmits one color light and reflects another. I don't know how it's done, but expensive as they are, I'm not surprised that they do it so well!

The dichroic/mirror system separates all visible light into one of three vidicons. Now, what about colors that are neither red, green, nor blue? Are there any colors that never get transmitted at all? Yes! This is where all that psycho-visual testing (see part 1) came in: to determine which color frequencies we could do without. As it turns out, by combining the primary colors (red, green, and blue) colors, not enough gets left out to be easily noticeable. This is fortunate because we have only three colors to work with when we play the whole thing back. Fortunately, with only three colors, we can fake just about any color necessary. White is a combination of all three colors — but not in equal parts; 30 percent red, 59 percent green, and 11 percent blue gives you white. Now do you see why TV is such fun?

As I said in part 1, when no color information is present on a video signal, we have no 3.58-MHz subcarrier. Our video signal contains only luminence or brightness information. This occurs when the output from all three vidicons is in the 30:59:11 ratio. We achieve this by means of quadrature modulation or "IQ" modulation. "IQ" stands for "in phase and quadrature." (Quadrature simply means 90 degrees out of phase.) Although some knowledge of trigonometry is helpful in understanding quadrature modulation, it's not essential. Basically, it consists of adding two carriers at 90 degrees and allowing them to add or subtract from each other by shifting their relative phases. **Figure 6** shows this action. The top drawing shows the normal 90-degree phase between and I and Q. The middle shows the Q shifted to the left so that the two signals are in phase (0 degrees shift) and add. The bottom shows the shift to the right of Q and how the signals cancel out, leaving no amplitude on the resultant. In every case, though, the individual I and Q amplitudes are the same.

#1 Source of PACKET Info

CTM

The Magazine

For Amateur Radio and Computerists

Why You Should Subscribe!

Read what our subscribers say!

It's in the fine print!

•*Your magazine is the finest innovation that I have seen in ham radio since 1953—except... maybe the all-solid state tranceiver.* **Carl Soltesz, W8PFT** • *...have most certainly received my money's worth in software...* **Michael Regan, K8WRB** • *...you have found a nice niche for CTM in packet... you have me getting interested...* **Charlie Curle, AD4F Chattanooga, TN** • *The packet computer info convinced me to subscribe.* **John Skubick, K8JS** • *Enclosed is my check for renewal of my subscription. I enjoy the down to earth and homey style of your magazine and the many fine computer articles...* **Andy Kosiorek, Lakewood, OH** • *I was both pleased and dismayed upon becoming acquainted with your magazine at HAM-COM. Pleased that I discovered your magazine—dismayed that I didn't long before now.* **Bill Lathan, AK5K** • *...CTM gives the finest coverage to packet radio that I have seen in any of the computer or amateur radio magazines. It would appear that CTM has just the right blend of packet amateur radio articles and computer articles.* **Barry Siegfried, K2MF** • *Of the three HAM magazines I received each month* **CTM** *is the only one I read from cover to cover and carry with me during my travels abroad. Most of the time it remains in that country.* **Buck Rogers, K4ABT**

U.S.A. $18.00 1 Yr—$10.00 6 Months (Limited Offer) $33.00 2 Yr
Mexico & Canada $32.00 1 Yr (Surface)
Other Countries (Air) $68.00 (Surface) $43.00 1 Yr
U.S.FUNDS ONLY
Sample Copy & Back Issues—$3.50

Mail to:
Circulation Manager
1704 Sam Drive
Birmingham, AL 35235
(205) 854-0271

Name _____

Call Sign _____

Address _____

City _____ **ST** _____ **ZIP** _____

Date _____

Signature _____

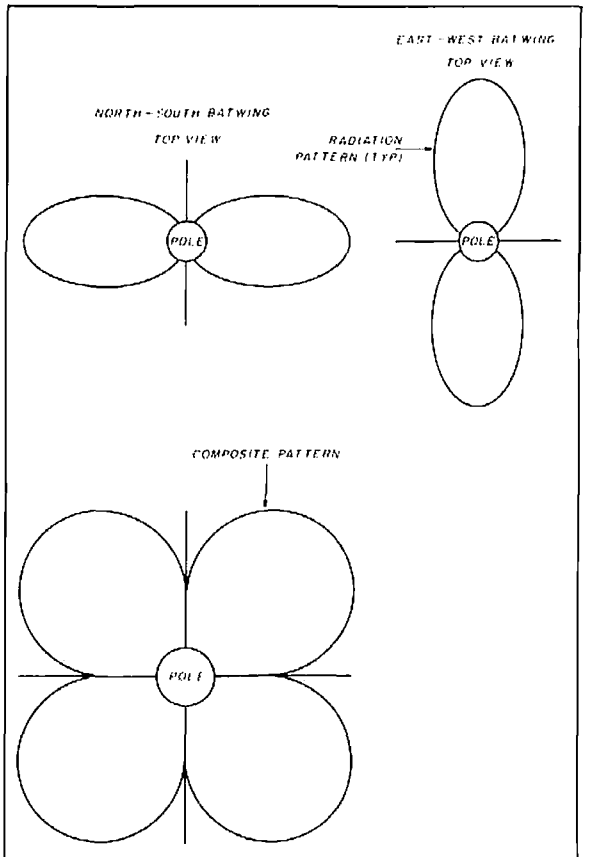


fig. 9. Combining of dipole patterns.

balanced modulators

The actual phase shifting is accomplished with balanced modulators, the inner workings of which are beyond the scope of this article. Also in real life, the I and Q are both shifted, but in opposite directions. Now the only trick is to arrange things so that the condition of **fig. 6C** prevails when no color is present. In other words, we have to put the information from three cameras onto only two axes. This process consists of what's known as matrixing, and a matrix is nothing more than a bunch of precision resistors. The sum of I and Q modulator outputs will be 0 (no carrier) when the output from each of the matrices is equal and opposite in polarity. Keeping in mind that magical 30:59:11 ratio, we find that with the given resistor values, this will occur when the output from each gun is equal. (I'm not going to do all the addition here, so take my word for it!) All that's left is for us to do a couple of 180's and our signals will cancel rather than add. (Notice the 180-degree phase shifters in the I and Q matrix.) The point here is that we have combined three guns into two modulators. Now if anything changes to upset the balance of our guns, such as when the input includes color, our balanced modu-

151

lators will be unbalanced, allowing some 3.58-MHz carrier to leak out. This carrier will be compared in phase to the color burst in our receiver (see part 1) and decoded to give the right color.

the switcher

Now that we've generated a color signal with our camera, we need to run it to the switcher, the brains of the TV station. A TV switcher is just a switchboard that selects video sources. However, it must do so without introducing any visible glitches. It does this by switching during the vertical interval, that period of time between the frames when nothing is showing. How does the switcher know to do this? That's right; it's fed sync from the DA system.

When you push a button to select another camera or, for example, a VCR, the switcher waits a 30th of a second or so until it sees a vertical sync pulse and then throws the switch. In actuality, the switches in the video path are saturated FETs, which make almost ideal video gates.

Switchers can do other things besides selecting sources. They can do fades, wipes, and synthetic coloring. Switchers that do this are called SEGs, or special effects generators. A vertical wipe is easy; all the switcher does is wait a precise amount of time after the vertical interval to switch from one source to the next. This timing is selected by a joystick or fade/wipe bar. As the bar is moved down, it merely increases the delay time between the vertical interval and switchover time. For those of you familiar with test equipment, this is identical in function to the "delayed sweep" mode on an oscilloscope.

After we do our switching, we need to run our signal to our transmitter. If our transmitter is on a distant hill, we send our video to a studio transmitter link (STL), which is no more than an fm microwave transmitter operating at 2, 7, or 13 GHz. STLs are extremely wideband; this allows us to get video from point A to point B with no measurable distortion.

Before we feed our STL or transmitter, we usually run our video through a processing amplifier or "proc amp." This device cleans up any garbage our sync pulses have accumulated in their course through the switcher. Also, unless you're using 2-inch quadruplex videotape equipment, the sync level is going to be pretty lame even before it gets to the switcher. For some reason, 3/4-inch and 1/2-inch helical VCRs can't reproduce a decent sync pulse. The proc amp also allows us to adjust color burst amplitude and phase, and to set overall video modulation and setup level. It's sort of a final inspection before the signal hits the airwaves.

The first thing our video sees when it reaches a transmitter is a receiver equalizer or "predistorter" that compensates for delay time errors all TV receivers experience because of the intercarrier sound system mentioned in part 1. Rather than require that receivers fix their own problems, the FCC makes the broadcaster compensate for poor receiver design by introducing the opposite problem at the transmitter; hence the name "predistorter." Without receiver equalization, a color receiver has a comic effect; this is caused by the color information taking longer to get through the receiver circuitry than the luminence information. So the receiver equalizer introduces an equal but opposite frequency vs. time delay before it even gets to the transmitter. The receiver equalizer uses circuits known as all-pass filters to do this.

After we've butchered our perfectly good video with our receiver equalizer, we run it into an optional differential gain corrector. This is similar to a gamma corrector except in that it compensates for nonlinear responses in the power amplifier of the visual transmitter. Usually this circuit is bypassed when the tubes are new. As they get "soft," we can start adding gain correction. When the gain corrector can no longer do the job, we change the tubes. (Not a pleasant task at a minimum of $5000 for a moderate-power VHF transmitter. The price rises to $35,000 for a typical UHF transmitter.)

From here, it goes into an endless variety of modulators. The trend these days is to use a low-level modulator so we can use the same exciter to run any power level of transmitter. Our output power is then determined by how many stages of linear amplifiers (afterburners) we want to use. Our Harris BT5L transmitter uses a diode ring modulator, similar to the type used in many Amateur SSB transmitters. This system is very linear and broadbanded — i.e., high fidelity. Next we eliminate the lower sideband with a novel type of filter called a SAW (surface acoustic wave) filter, which is actually an electromechanical device that uses the properties of shock waves rippling across a piezoelectric crystal to achieve very precise frequency filtering. It requires no adjustments or tuning.

All this is done at about 37 MHz. From here, it's converted to the channel of operation. Almost all TV transmitters are hybrid — i.e., they use both tubes and solid-state devices. Vacuum tubes still offer clear advantages at high power levels.

Next we take our high power output signal and run it through a diplexer. Doing this allows us to use the same antenna for both transmitters. Both the diplexer and antenna are designed for optimum bandwidth. The system must exhibit less than 1.05:1 SWR over a 6-MHz wide channel. The shape of the batwing antenna is the key to this bandwidth. By using two batwings positioned at right angles and fed 90 degrees out of phase electrically, we can achieve a nearly circular radiation pattern (see **fig. 9**).

Figure 10 gives a crude explanation of how a bat-

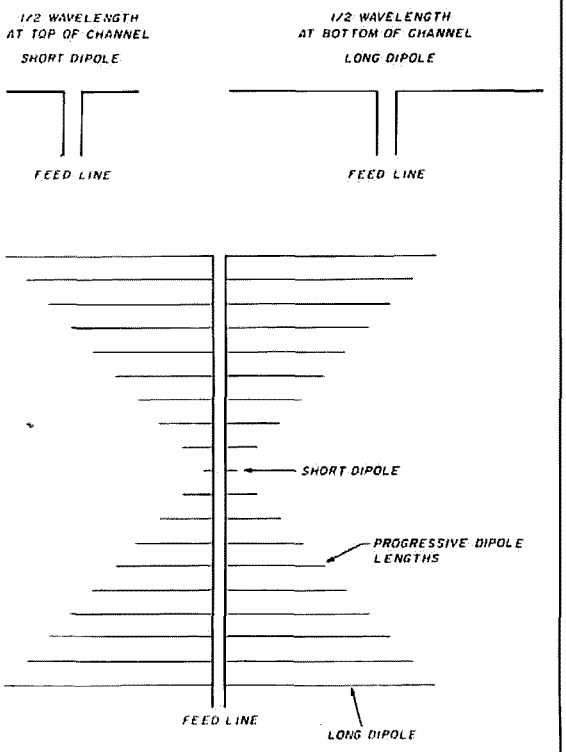


fig. 10. Evolution of batwing.

wing shape ensures broad bandwidth. The short dipole is resonant and works well at the top end of the channel. The long dipole is resonant at the bottom of the channel. By making a batwing sheet, we actually have an infinite number of dipoles of different length. Any frequency signal falling within the 6-MHz limit will find a dipole of the correct length. This scheme has no effect on the directional characteristics of the system. Batwing antennas are all horizontally polarized. Circularly polarized TV antennas follow configurations other than the batwing, but that's a different subject altogether.

One major refinement of the batwing that makes this description a little too simple is that these things are firmly bolted to a solid steel pole. A few tricks are necessary to make the pole look like it isn't there, electrically speaking. Because the use of insulators is prohibited mechanically, the problem becomes even more amusing; actually, it isn't as difficult as it may seem, though it does requires some understanding of advanced transmission line theory. We use the principal of shorted stubs, sometimes facetiously called "conductive insulators."

Speaking of transmission lines, these antennas are fed with 50-ohm transmission line, which is standard practice for RF power applications. Unlike flexible coax, 50-ohm TV transmission line measures 1-1/2 inches in diameter, contains solid copper pipes for both inside and outside conductors, and is *very* expensive . . . but then again, so is most of the materials and equipment that are used in TV.

Though I've now described a TV station from vidicon to antenna, I've obviously left many questions unanswered. But by now you should at least know what those questions are. As I mentioned at the beginning of part 1, NTSC isn't the perfect system, but it works.

If you think you could do the job better, you're probably right — and there's probably a TV station somewhere that could use your ideas.

ham radio

ENHANCE PERFORMANCE

The Ultimate Upgrades!

Drake R-4B/C, TR-7, R-7, TR-4/C, SPR-4, SW-4A
First & Second IF Filters, P.C. Board Retrofits
JRC NRD 515 Filters + Motherboard Modifications

Speech Processing + IF Filters: T-4XC, TR-7, CX-11A

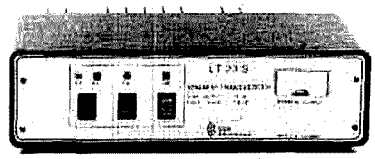
Front-End Antenna Filters: 160, 80, 40, 20, & 15 M
High-Performance SSB & Phase-Locked AM Detector
Improved HF Mobile Antennas, 80-10 m 40-10 M
Atlas and Signal/One Filter Improvements

Receiver / Transmitter Modification Services
Alignments, Receiver Testing, Filter Plots

Sherwood Engineering, Inc.

1268 South Ogden Street, Denver, CO 80210
(303) 722-2257 8:30 A.M. - 5:30 P.M. Mountain Time
Visa, MasterCard, Choice cards welcome

153



SSB ELECTRONIC TRANSVERTERS & PREAMPLIFIERS

LT 2S	144/28 XVRTR 20W GaAsfet DBM	$549
LT33S	902/144 Xvrtr 20W GaAsfet	$599
LT23S	1296/144 Xvrtr 10W GaAsfet	$549
MICRO-13	2304/144 XVRTR 0.5W GaAsfet	$429
MICRO-X	10368/144 Xvrtr 0.1W GaAsfet	$599
DX	series low noise GaAsfet preamps from	$129
MV	series mast mounted GaAsfet preamps	$199
K	series rx cnvtrs GaAsfet DBM from	$129

TRANSVERTERS UNLIMITED

T220/28	220 MHz Xvrtr 28 or 50 IF, 20 W	$220
T144/28	144 MHz Xvrtr 28 or 50 IF, 25 W	$199
PA33200	902 MHz 2 tube PA, 200W +	$499
PA23150	1296 2tube PA, 150 + W	$449
PA1325	2304 1tube PA, 25 + W	$429
HF400	High power relay 2Kw at 144 MHz	$129
RK500	Medium power relay 1KW at 144 MHz	$ 69

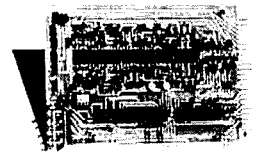
Factory Authorized Dealer for SSB Electronics for North America

TRANSVERTERS UNLIMITED
BOX 6286 STATION A
TORONTO, ONTARIO
CANADA M5W 1P3
(416) 759-5562

TRANSVERTERS UNLIMITED (US)
P.O. BOX 178
NEW BOSTON, NH 03070
(603) 547-2213

154

THE MULTIPLE RECEIVER SOLUTION



4 Channel Signal-to-Noise Voter

- Expandable to 32 Channel by Just Adding Cards
- Continuous Voting
- LED Indicators of COR and Voted Signals
- Built-in Calibrator
- Remote Voted Indicators Pinned Out
- 4½ x 6 Double Sided Gold Plated 44 Pin Card
- Remote Disable Inputs
- MORE

Built, tested and calibrated with manual

$350.00

Telephone interface now available
For more information call or write

HALL ELECTRONICS
Voter Department
815 E. Hudson Street
Columbus, Ohio 43211
(614) 261-8871

155

ode to older oscilloscopes

handy boat anchor monitors i-f, tunes RTTY signals

Old tube-type oscilloscopes are often available at flea markets at very little cost. Until the 1940s and 50s or so, oscilloscopes produced for most technical work were "recurrent sweep" models. This meant that the spot of light on the tube face swept continuously across the tube face, whether there was a signal to monitor or not.

Shortly thereafter the design of general purpose scopes underwent several dramatic changes. Older scope designs were inadequate for the tasks demanded of them by technicians and engineers. As newer designs evolved, the recurrent sweep type was replaced by the "triggered" sweep, in which the spot of light on the tube face swept across only when there was a signal present. By allowing the signal to control the sweep, a much more stable visual display was obtained. Better response at higher frequencies was another welcome improvement.

The newer scopes were easier to use, and would do things that the older models would not: for example, they would provide more accurate traces of higher frequency signals than the older ones. The sometimes jumping, jittery trace of the older recurrent-sweep scope was now replaced with the rock-solid, easily controllable, triggered trace.

The newer scopes were such a pleasure to operate that, by comparison, the ones they had replaced came to be viewed as relatively worthless relics.

Although the really worn-out older scopes are probably better left on the scrap heap, many of them are still in fair shape, and remain good performers for some uses. Note that I say "some uses." I don't mean to suggest that the older models are at all comparable to today's scopes in performance; they are not. On the other hand, the older scopes can perform several tasks that are of considerable interest to many hams and radio buffs, and do them quite well. Let's take a look at some of these applications.

rf applications

One useful application is the viewing of signals tapped from your receiver's i-f section. Some receivers and transceivers have an output jack for this function. When used in this application, your scope trace will show you such things as the modulation characteristics of received signals in phone work, or the keying characteristics of CW signals (see **fig. 1A** and **1B**).

Once I was given an older scope when I bought some other items at a flea market. Sometimes these old scopes work without repair; others may need minor repair. Luckily I found that all mine needed was the replacement of two tubes. *If you tinker with the innards of an oscilloscope, remember that there are very high voltages in most of these units.* Reduce the chances of sending an electrical current through your heart by following the slogan, "One hand in the circuit, one in a pocket." My "free" scope now sits alongside my operating table (see **fig. 2**). Using it to view signals from my transceiver's i-f, I find it's a pleasure to be able to check the received signals by just glancing at the CRT. Such an accessory provides an education in judging signal characteristics.

Other rf applications for some of these scopes stem from the fact that, on various models, there was a means of connecting the test leads from rf signal sources directly to the deflection plates of the CRT itself! To locate the connections to these plates, look for a small porthole on the side of the case, near the neck of the CRT. The direct connections were neces-

By W. Clem Small, KR6A, R.R. 1, Box 181, Salisbury, Vermont 05769

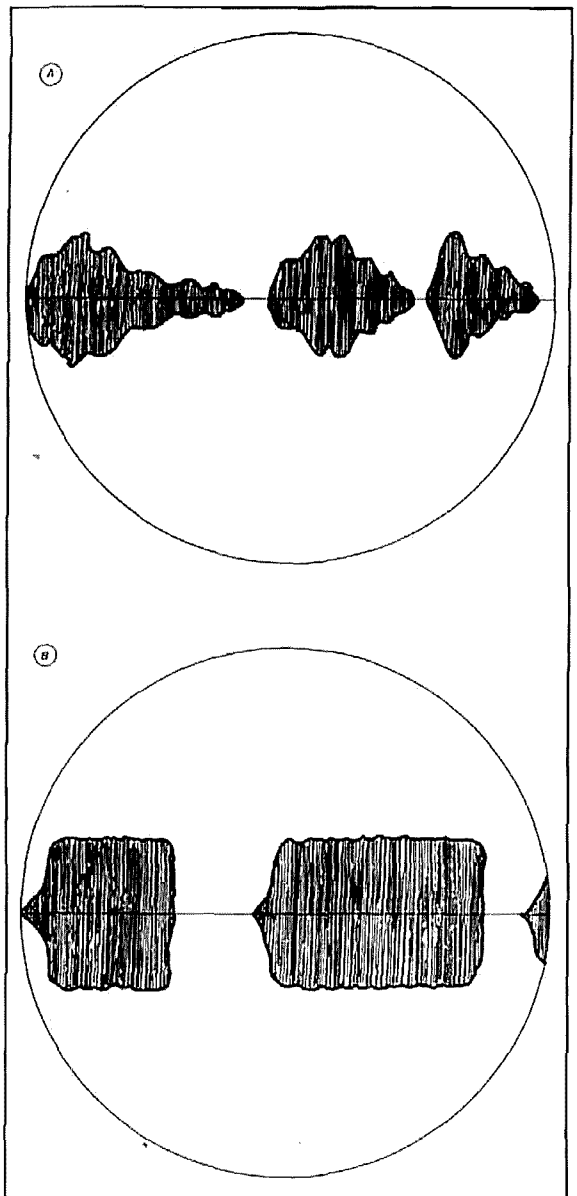


fig. 1. Scope traces: (A) sideband signal; (B) CW signal.

sary for rf work because the amplifiers used in these scopes had a much lower frequency response than those used in modern scopes. So by going directly to the CRT tube elements and bypassing the amplifiers, the amplifier-response problems were solved! By this direct-connection method, the older scopes could be used to view rf signals in the hf region and beyond.

Most radio handbooks include examples of other applications appropriate for these older scopes.

tuning indicators

RTTY, AMTOR, and other popular modes of communication perform only when the received signals are properly tuned in. Many of the interfaces in use for these modes of communication have outputs that can be connected directly to the inputs of the older scopes. The ease of tuning in a reluctant RTTY or AMTOR signal with a scope indicator can be appreciated only by one who has experienced it (see **fig. 3**). The new LED tuning indicators do work to a degree, but when it comes to tuning in a difficult signal, they don't hold a candle to an oscilloscope of any vintage. The older scopes are superb for this application. (I have a small, old Heathkit scope that's great for this job. That scope is located above, and to the right of the transceiver — see **fig. 2.**)



fig. 2. Two recurrent-sweep scopes are used; larger to monitor receiver i-f, smaller as RTTY tuning indicator.

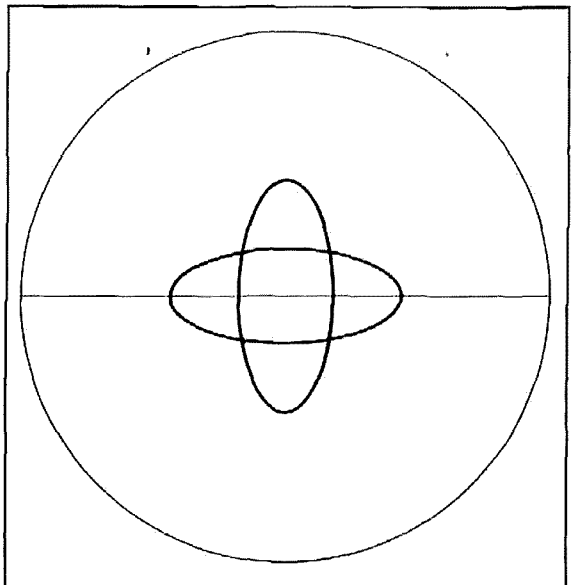


fig. 3. Common ellipse pattern seen when turning the mark and space of an RTTY signal.

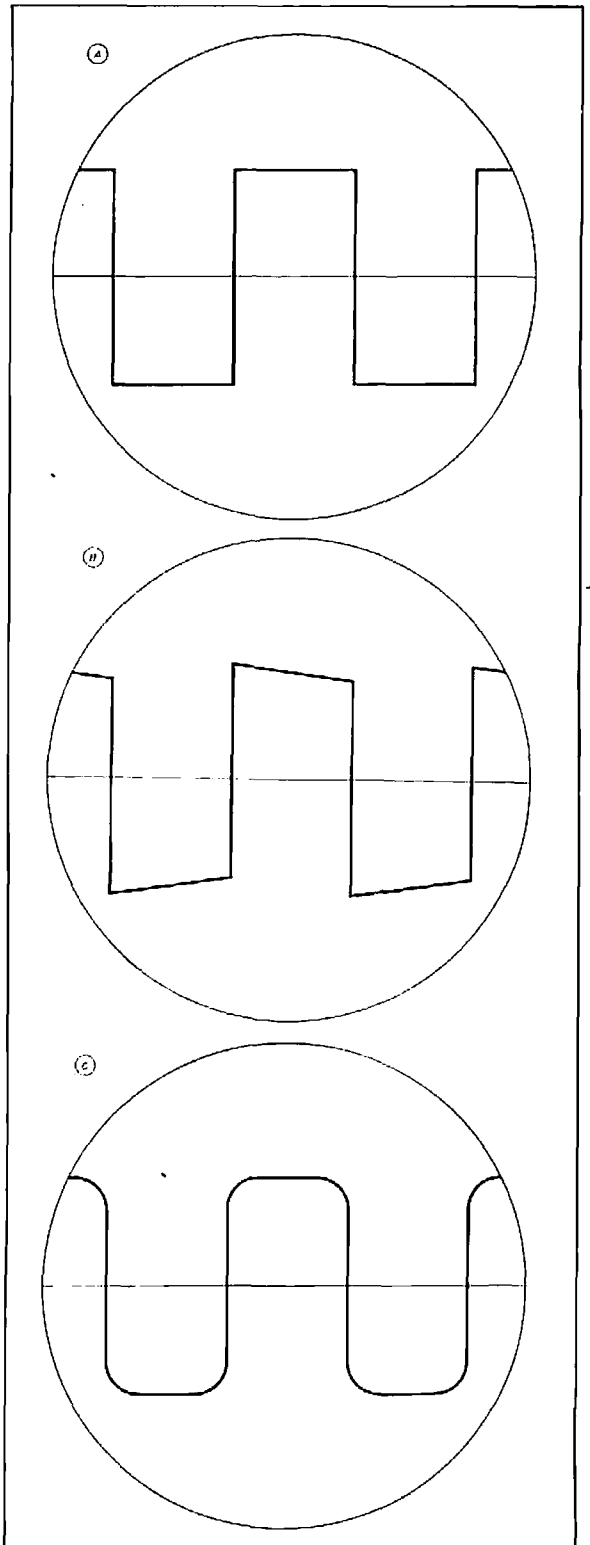


fig. 4. Oscilloscope waveforms: (A) undistorted square-wave; (B) square-wave output from circuit with poor low frequency response — notice tilt on "flat" portions; (C) square-wave output from circuit with poor high frequency response — notice rounding of corners.

audio too!

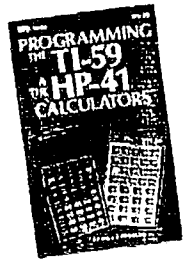
We mustn't forget that the old scopes did a pretty fair job in audio work. Looking for distortion, clipping, and the like is a simple matter with a scope. Figure 4 gives an idea of how easy it is to see distortion present in audio signals.

Next time you come across one of yesterday's oscilloscopes, think of all the fun — and even education — that you can get by applying one or more of the ideas covered above. With the price range of contemporary scopes in the hundreds and even thousands of dollars, using yesterday's scopes today isn't such a bad idea after all.

ham radio

CLOSE OUT TITLES

SPECIAL PURCHASE FROM THE PUBLISHER ALLOWS US TO SLASH THE PRICES ON THESE BOOKS



PROGRAMMING FOR THE TI-59 AND HP-41 CALCULATORS
by Paul Garrison
To take full advantage of your hand-held calculator's power, you need to learn how to program it. Clear easy-to-understand instructions make programming a snap! Over half the book has practical programming applications that will solve some very complex problems. 1982, 294 pages.
T-1442 Was $12.95 SAVE $8 Softbound $4.95

MICROCOMPUTERS IN AMATEUR RADIO
by Joe Kasser, G3ZCZ
Computers can be used in a number of different ways in your Ham shack. They can be used to control your rig, predict propagation, control antennas and hundreds of other applications. Kasser explores the possibilities in this book. Includes interface I/O devices, system categories, programming the microcomputer and much more. Great reading. 1981, 307 pages.
T-1305 Was $15.95 SAVE $11.00 Softbound $4.95





SOFTWARE FOR AMATEUR RADIO
by Joe Kasser, G3ZCZ
Packed with practical computer applications and tested and de-bugged programs that can be simply adapted to almost any microcomputer. Includes BASIC programming concepts as well as how to interface your computer to your radio, digital communications and more. 1984, 284 pages.
T-1560 Was $15.95 Softbound $4.95 SAVE $11.00

BUY ALL 3 SPECIAL $44.85 VALUE at retail
☐ **T-SPB** **$10.95**
SAVE $33.90 WOW What a Deal!!!!!!!

ham radio magazine BOOKSTORE
GREENVILLE, NH 03048 *603-878-1441*

PRACTICALLY SPEAKING ... Joe Carr K4IPV

drift and shift

Few circuit problems are less welcome than frequency drift — a gradual change of frequency, usually as a function of temperature — and shift, an abrupt change of frequency. Although the causes of these two related phenomena are different, they're often confused with each other.

There's also a difference between problems with new projects and drift in old equipment that once worked well. In a newly constructed project, or in new equipment from less reputable sources, the problem may well be an inherent error in the design. Some of these errors are easily corrected, while others are not. In equipment that once worked well, however, it's more likely a matter of a failed component.

frequency shift problems

Resonant circuits in modern electronic equipment might be LC tuned by a combination of inductance and capacitance, or tuned by a piezoelectric resonator element ("crystal"). In either case, the cause of a sudden unwanted shift of operating frequency is usually related to some form of mechanical trauma somewhere in the circuit. In other words, some component has either broken down or suffered an intermittent connection.

Figure 1 shows a partial circuit of an oscillator. The resonance of this circuit is determined by the combination of C1, C2, C3, and L1. If any of these components fails, changes value, or becomes disconnected, then the resonant frequency of the circuit will shift. If coil L1 fails, the circuit will probably cease oscillating, so the fault will be obvious. But what if one of the capacitors fails? In that case, the circuit may well continue oscillating, but at a different frequency than before.

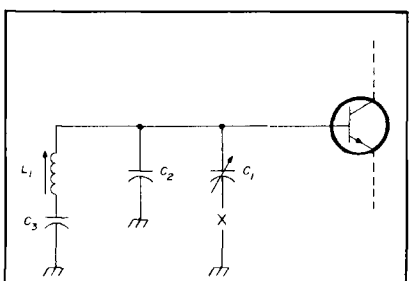


fig. 1. Frequency-setting components of a variable frequency oscillator.

The trimmer capacitor was selected for our example in **fig. 1** because those components seem especially at fault. After many years of experience, I can attest that trimmers seem to have a high casualty rate. Perhaps the worst offenders are the half-turn type that use silver deposited on a pair of ceramic surfaces. The mica compression types also fail, but at a lower rate than the other types. The failure mechanism seems to be looseness in the adjustment screw. Tap the capacitor gently with an insulated probe, and note whether or not the shift occurs.

Don't make the mistake of assuming that the other forms are fault-free — far from it. Every form of fixed capacitor has at least a small failure rate, with failure usually attributable to disconnected leads inside the body of the capacitor.

Also, don't overlook the possibility that the problem is due to the solder connections on the capacitor, especially where the capacitor is mounted on a printed circuit board that flexes easily. Although some bad joints slip past the eye of the factory Quality Assurance (QA) inspector — and subsequently last for years before failing — others die an early death because of trauma or flexure of the board. In addition to solder joint breaks, it's also possible that the printed wiring track is cracked. In both cases, a little solder and a hot iron will solve the problem.

One of my colleagues is a ham who has a receiver-transmitter pair that was once the top of the line in Amateur circles. He noticed that the formerly very good receiver dial calibration was now about 25 kHz off. On inspecting the local oscillator VFO circuit, he found that the LO VFO contained a number of small fixed capacitors in addition to the frequency-setting trimmer and the main tuning variable capacitor. He made a few quick calculations of resonance to see which, if any, would result in about 25-kHz shift if it were open. He quickly identified a 27-pF unit that was part of the tem-

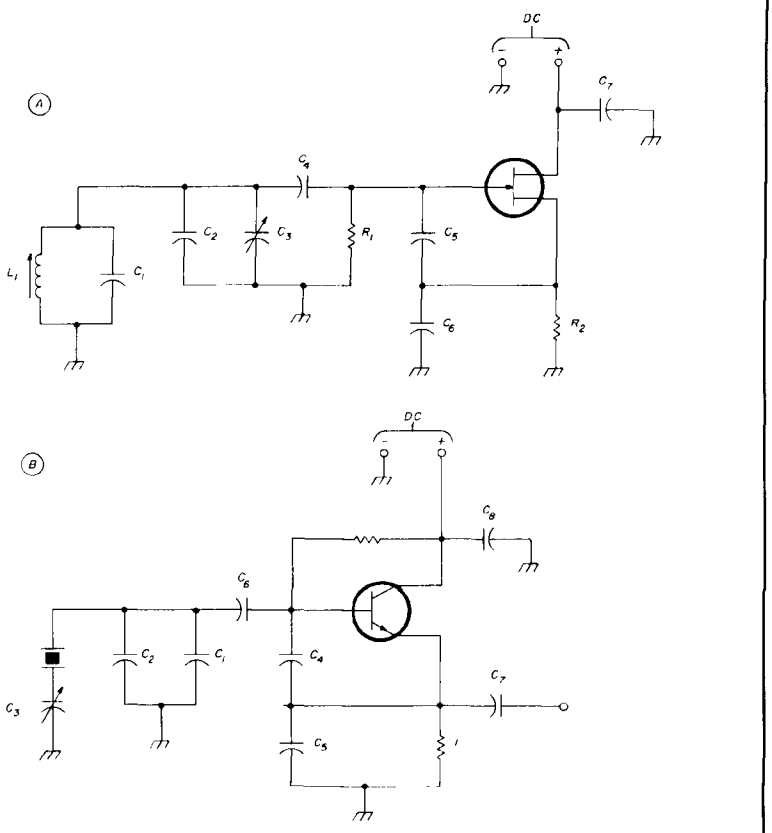


fig. 2. (A) LC-tuned VFO showing resonant tank circuit: (B) Piezoelectric crystal oscillator.

perature compensation circuit. A new 27-pF N1500 unit solved the problem.

When you find a disk ceramic capacitor with a specified temperature coefficient, please don't make the mistake of thinking that a low-temperature coefficient type is a better replacement. And don't use another disk with a different temperature coefficient!

On older receivers, be sure to examine the main tuning capacitor for problems. I once had a terrible problem with a piece of equipment that exhibited both shift and drift in magnificent proportions. Although employed in a communications shop at the time, I didn't get around to fixing the receiver for several months (the cobbler's kids go-without-shoes syndrome). When I looked into the problem, it turned out to be dirty grease under the rotor grounding spring on the main tuning capacitor. That capacitor rotor is normally grounded to the chassis through its own frame. But because the rotor must move, a brass or steel grounding leaf spring or "spider clip" is usually placed around the rotor at the front bearing. The spring or clip grounds the rotor to the frame. But in that case, dirty grease had built up under the spring. Rather than causing operation to cease, however, the grease caused massive frequency shifts, drift when it wasn't shifting, and a sad tendency towards microphonics.

Another problem in older receivers is poor grounding. I've seen frequency shift problems in many car radios, in two-way radios, and in other rf equipment caused by poor grounding or cracked ground tracks on the printed circuit board. In one infamous fm model, the fm front end was grounded at only two points on the printed circuit. If that wasn't bad enough, the ground ran around the edge of the card, and was stressed at one point. . . where cracks tended to develop. Although the circuit wouldn't cease oscillating, the extra several inches of ground line on a flexing board caused operating frequency shifts. I suspect that the cause of the frequency shift was the added inductance of the printed circuit ground path.

At VHF frequencies the effect of distributed inductance and/or capacitance is more profound than at low frequencies. Again, judicious use of a soldering iron not only repaired the break but also added strength to the weak point.

frequency drift problems

Unfortunately, most electronic components exhibit some temperature sensitivity. This sensitivity is usually measured in terms of a temperature coefficient which specifies a certain shift of value in parts per million (PPM) per degree Celsius of temperature change. The temperature coefficient (or, casually, "tempco") can be either positive or negative. A positive temperature coefficient (PTC) indicates that the component value will increase as temperature rises and decrease as temperature falls. A negative temperature coefficient (NTC) indicates that the value will decrease as temperature rises and increase as temperature falls.

Most inductors used in oscillator circuits have a PTC problem. The value of inductance (in microhenrys) is determined by the coil dimensions and the number of turns of wire. While the turns count remains constant, the diameter, length, and size of the wire used in the inductor are temperature-related.

The temperature coefficient of inductors can be minimized by design. If the inductor uses Litz wire (or some other low-tempco wire) and a low-tempco coil form, then the temperature coefficient is reduced tremendously. Old-fashioned cardboard forms are terrible sources of drift. According to

standard wisdom, the best forms are ceramic, but that that's not true any longer. Fiberglass and other synthetic materials now provide better tempco characteristics.

Capacitors are also sources of temperature coefficient problems. Ceramic capacitors are available in either PTC, NTC or no-TC versions. Markings of "Nxxx" and "Pxxx" indicate the direction and value of the temperature coefficient. For example, an "N750" is an NTC device with a tempco of 750 PPM. The capacitor marked "NPO" has a low tempco, but it isn't precisely zero — as some people find out to their chagrin when they try to substitute really low-tempco caps with NPO ceramic units. In general, silver mica and polystyrene capacitors are the lowest-tempco units available.

So why not make all capacitors with low or nearly zero tempcos? Because they're sometimes used in temperature compensation circuits. **Figure 2** shows two forms of oscillator, one LC tuned and the other crystal tuned. Both of these oscillators seem to have "extra" capacitors in the circuit (for example, C2 in **fig. 2A** and C1 and C2 in **fig. 2B**). In these cases, the extra capacitors are used for temperature compensation. They typically have small values compared with other circuit capacitors, but have precalculated temperature coefficients that will cause the capacitance to change a predictable amount with changes in temperature. Both circuits, even the crystal oscillator, will change frequency with changes in circuit capacitance, so the tempco of the compensation capacitors forces the frequency to change in a predictable manner. The idea is to counter the positive temperature coefficient of the inductor with an equal and opposite direction temperature coefficient of the capacitors.

Unfortunately, even some manufacturers don't understand drift. Several years ago, in my column for *Worldradio*, I passed along a request for information sent in by an Amateur working in the jungles of central America. He had a low-cost transceiver that had made a brief splash on the Amateur market. His problem was that it drifted badly, and, in fact, had always drifted, even when it was new. My request was answered by an engineer at Stoner Communications who passed along the information that the rig had been designed by a consulting design engineer whose reputation is spotless. His name is well known to technically oriented Amateurs, but in this case I suspect he would prefer to remain anonymous.

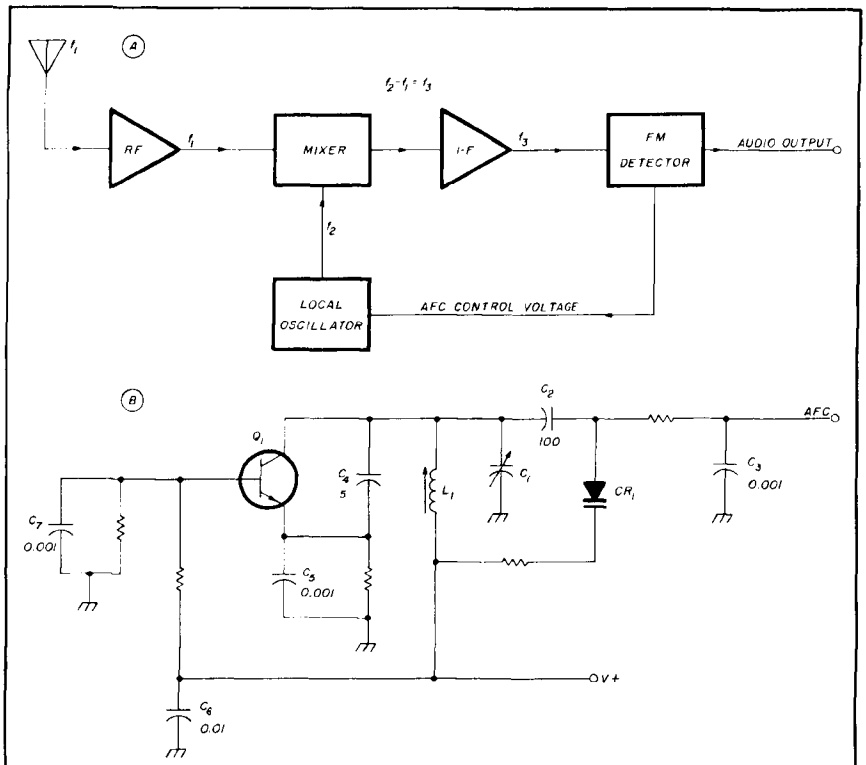


fig. 3. (A) Block diagram of a VHF-FM receiver. (B) VHF-FM receiver local oscillator with varactor automatic frequency control.

The designer reported that the original prototypes and first production units had a drift spec of 100 Hz in the first 15 minutes, and 50 Hz per hour thereafter . . . not terrific, but good enough for an inexpensive rig. The early rigs actually met the specification. So what happened?

According to the designer, the original design used Litz wire in the VFO inductor and a special low-tempco fiberglass form. The VFO also used DM-25 silver mica capacitors, except for a couple of ceramics used for temperature compensation. The inexperienced manufacturer, however, had employed a "kid technician" to redesign the rig to make it cheaper to produce. He replaced the Litz wire with enameled wire, the coil form with an off-the-shelf ceramic type, and the DM-25 SM capacitors with NPO disk ceramics. The result was a disaster.

Figure 3A shows the block diagram of an fm receiver. The local oscillator (**fig. 3B**) is kept on-channel by a dc control voltage from the automatic frequency control (AFC) output of the fm detector stage. The actual mechanism of frequency control is the variable capacitance (varactor) diode in the oscillator circuit (CR_1 in **fig. 3B**). This type of diode is used in both LC-tuned circuits, as it's used in broadcast receivers as well as in crystal-controlled units used in communications equipment. If the varactor becomes defective, it will cause a frequency

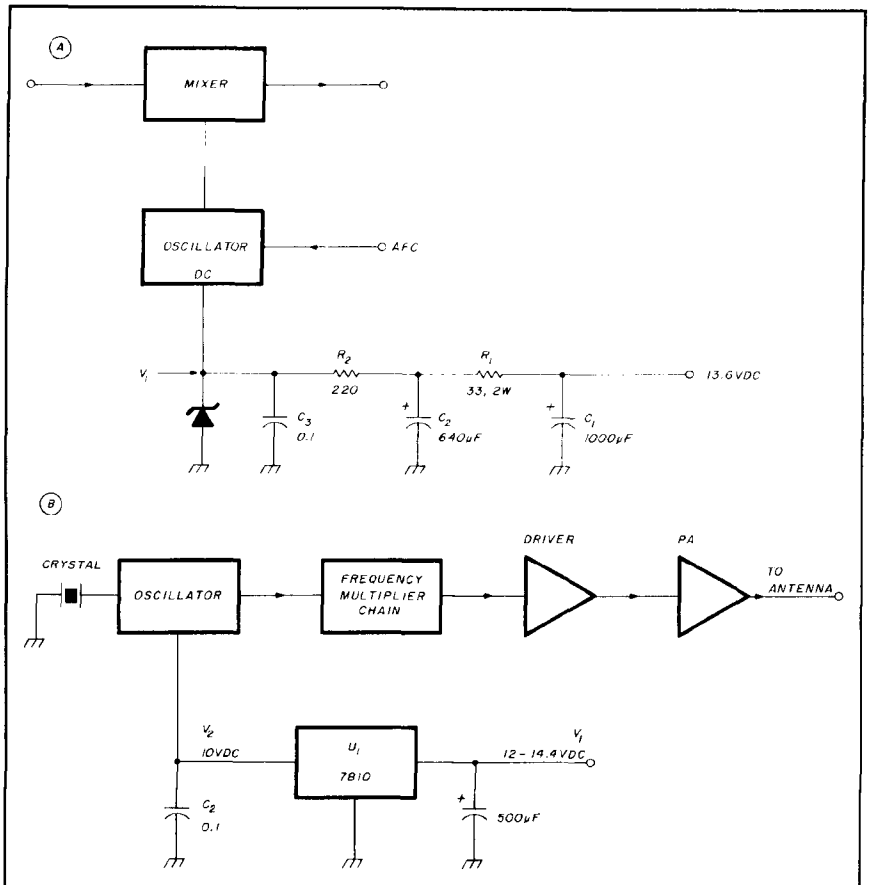


fig. 4. (A) Zener diode used to regulator supply voltage to receiver local oscillator. (B) Three-terminal IC voltage regulator used to stabilize local oscillator supply voltage. The IC regulator tends to be superior to zener regulation.

shift; on the other hand, if the diode is intermittent, the circuit will jump on and off the channel as the diode opens and closes the circuit. Over the years, I've seen, however, quite a number of sets in which a newly developed (as opposed to inherent) drift problem was caused by a defective diode. For some reason, the diode capacitance was a function of temperature. I once measured — more casually than scientifically — about five diodes that showed this effect, and found that all had excessive leakage resistance in the reverse-bias direction.

Don't overlook the dc power supply as a potential source of drift problems! Oscillators typically require fixed, well-regulated dc operating potentials for best stability. That dictum applies equally well to both LC-tuned and crystal oscillators. If the dc voltage, or bias voltages, change, you can expect the oscillator frequency to shift.

The problem with dc voltage is especially acute in mobile equipment, whether designed for communications or broadcasting. In the early 1960s I worked in a car radio shop that dealt with Blaupunkt receivers, the German-made radios found in Porsches, for example. One customer came in with an odd problem: his radio changed frequency with changes of engine speed. That set, which used vacuum tubes, had a germanium diode across the resonant circuit to limit oscillation amplitude. A gas-regulator tube that was supposed to keep the potentials applied to the circuit was defective. Because the power supplied to the radio varies markedly with engine speed, the now-unregulated power supply voltage applied to the oscillator also varied. Although I frequently chuckled at customers' diagnoses, I never again doubted this customer's description of the symptom: " . . . it changes stations when I pull away from a light!")

Modern mobile electronic equipment is probably more subject to this type of fault than some of the older equipment. In communications equipment and fm broadcast receivers, the oscillator voltage is typically regulated. In **fig. 4A** we see the zener diode regulator generally used in many car radio circuits; in **fig. 4B**, we see the three-terminal IC voltage regulator that keeps the oscillator voltage to +10 volts in a certain mobile transmitter master oscillator. If any of these components fail, shift or drift will result.

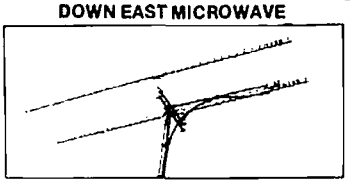
The nominal "12-volt" vehicle power supply is actually quite variable. With the engine off, my own car measured 11.8 VDC on one meter, and 12.05 VDC on my DMM. When the engine is started, however, the voltage varies from 12.3 VDC at an idle to 14.5 VDC as the engine speed is increased. To an oscillator inside electronic equipment, that range might be intolerable.

Crystal oscillators aren't immune to drift problems, even when they previously worked well. In addition to the problems with dc power supplies mentioned above, it's also possible for the crystal to become defective. Over the years, I've seen several sets in which a terrible drift problem resulted from defective crystal elements. Replacing the crystal solved the problem.

problems peculiar to older equipment

Certain older Amateur equipment exhibits a problem in frequency shift that's due to the use of ferrite cores in the VFO and i-f coils. Ferrite cores age with time and heat, and as a result have a different permeability than when the equipment was first calibrated. I've seen that problem even on the legendary Collins Permeability Tuned Oscillator (PTO) used in their Amateur and commercial communications equipment. In some cases, a simple realignment will suffice to bring the coil back to the correct resonant frequency. In

DOWN EAST MICROWAVE



MICROWAVE ANTENNAS AND EQUIPMENT
• Loop Yagis • Power Dividers • Linear Amplifiers • Complete Arrays • Microwave Transverters • GaAsFET Preamps • TROPO • EME • Weak Signal • OSCAR • 902 • 1269 • 1296 • 2304 • 2400 • 3456 MHz

2345 LY	45el	loop Yagi	1296 MHz	20dBI	$93
1345 LY	45el	loop Yagi	2304 MHz	20dBI	$80
3333 LY	33el	loop Yagi	902 MHz	18.5dBI	$93

Above antennas assembled and tested. Kits available.
All Aluminum and Stainless Construction.
Add $8 UPS S/H, $11 West of the Mississippi.
2318 PA Linear Amp 1W in 18W out 1296 MHz 13.5V. $245 ppd.
2335 PA Linear Amp 10W in 35W out 1296 MHz 12.5V. $295 ppd.

NEW! MICROWAVE TRANSVERTERS BY LMW ELECTRONICS
1296TRV6D 6W. GaAsFET. T/R Sequencer. Output Meter $569
2304TRV2D 2W. GaAsFET. T/R Sequencer. Output Meter $549

Add $6 for shipping UPS/48
Stripped down version, kits also available
Write For FREE Catalog
VISA DOWN EAST MICROWAVE
Bill Olson, W3HQT
Box 2310, RR 1, Troy, ME 04987
(207) 948-3741

175

QSO PRO
A Easy-To-Use Logbook Program For Your MS-DOS® Compatible Computer

★ Complete Cursor Control
★ Room to store complete address information
★ A Real-Time Log
★ Total QSL's by State
★ 900 QSO's on floppy, hard disk limited by space available



~~$39.95~~
Introductory Offer
$34.95*
*Ohio resident must add 5% sales tax.

Make Checks Payable To:
MORLAN SOFTWARE
P.O. Box 2400
East Liverpool, Ohio 43920-0400

176

other cases, replacement of the coil, or at least the ferrite core, is required.

Several years ago I had the opportunity to help a Novice on the air with a 20-year-old Heath DX-60B he bought for a song at the Gaithersburg Hamfest. He complained that keying was erratic: sometimes it keyed, other times it didn't. It rapidly became apparent by looking at the grid and plate meter readings that the oscillator wasn't running all the time. It turned out that the DX-60B crystal oscillator circuit uses a tuned plate circuit. The ferrite core of the coil had dried out over the years and mistuned the oscillator. Readjusting the coil made the oscillator run properly.

heat problems

Because the source of many drift problems is the temperature coefficient of capacitors and inductors, it seems obvious that temperature needs to be controlled in radio equipment. In the past, several otherwise well-regarded pieces of equipment suffered drift because of the tremendous heat buildup inside the cabinet. In some cases, ventilation and a blower might help; in other cases, using a little insulation in and around the offending oscillator is also helpful. In certain crystal oscillator circuits we can make progress by designing in a crystal oven to keep the crystal temperature constant.

equipment modification

Amateurs have a long tradition of modifying commercial equipment. Although many mods are ill advised, some are certainly worthwhile and well engineered. The process is a lot less dangerous, incidentally, if you make good notes so that the rig can be restored to original condition if the mod doesn't work out as expected. For most equipment, the first place to start is to make sure that the power supply voltage to the oscillator is stable. Check to confirm that the printed circuit board, its mounting, and individual components, are solidly anchored. Finally, make sure the circuit isn't overheating.

If those methods fail to solve the problem, then and only then dive into the circuit to attempt temperature compensation. We'll look into the subject in a future column. If you have any insight on procedures or techniques, please communicate them to me so that they can be shared with others.

conclusion

In many cases, the sources of frequency shift and drift problems may be difficult to detect. Understanding the causes and potential solutions of these problems goes a long way toward finding and correcting the fault.

I'd be happy to receive your comments, questions, and suggestions for future columns. My 1987 (and earlier) Callbook address is incorrect, so please contact me at P.O. Box 1099, Falls Church, Virginia 22041.

ham radio

A RACE ON THE EDGE OF TIME
Radar — The Decisive Weapon of WW II
by David E. Fisher

A Race On The Edge Of Time reads like a thriller but is based upon painstaking and comprehensive research by the author. In fact, Fisher argues rather convincingly that radar was the crucial factor that allowed the allies to win the war and that radar has played the same important role in our current military and political environment. Filled with fascinating twists and turns of history that could have changed the war's outcome, anecdotes about the personalities involved in the development of radar and other military insights. Also includes radar development post WW II and how it will influence future battles. Illustrated with rare vintage photographs and diagrams.

☐MH-21088 Hardbound $19.95

Please enclose $3.50 shipping and handling.



ham radio magazine BOOKSTORE GREENVILLE, NH 03048 603-878-1441



power speaker enhances mobile operation

Asked to name a problem that universally impairs the pleasure of operating most mobile stations, regardless of mode or band, most hams will say, "a serious lack of adequate receiver audio." This isn't surprising, considering the micro-sized speakers that are now standard in new radios.

Miniaturization isn't a problem in the average Amateur home station, where the sound produced by a 2-inch speaker is more than adequate, but it does present a problem when a radio is mounted under the dashboard of a car. Typically, the speaker ends up directing its puny audio towards the floor, away from the driver, and into heavy carpeting — with dismal results.

This weekender shows how to overcome that problem. My external speaker, combined with an integral amplifier, provides enough audio for any situation. Used with a radio equipped with an external speaker or earphone jack, it will produce several watts of loud, crisp audio. A few milliwatts of audio will drive it to full output.

You can also add this amplified speaker to any of the popular hand-held VHF transceivers. By doing so, you'll improve your audio and dramatically extend the life of your hand-held's battery. You may also find that other small portable radios, scanners, televisions, cassette recorders and similar items can also make good use of this project.

the circuit

The amplifier circuit is built around the LM383 IC, which I chose because it's stocked by Radio Shack and is carried by RCA SK replacement-device dealers. Actually, almost any audio IC intended for 12-volt operation and capable of delivering 4 or 5 watts of audio will work, providing the necessary circuit changes are made. **Figure 1** shows the schematic for the LM383 amplifier.

By Peter Bertini, K1ZJH, 20 Patsun Rd., Somers, Connecticut 06071

An input attenuator composed of resistors R1 and R2 reduces the audio level and prevents overdriving the amplifier. The 22-ohm resistor provides a low-impedance termination for the receiver audio stage. These three resistors weren't included on the pc board layout, but instead were mounted on a phenolic tie-strip to allow quick empirical substitutions to be made.

Negative feedback is used in this amplifier to improve its linearity and bandwidth and to set the closed-loop gain. The 2.7-ohm resistor sets the feedback level. (This value was optimum for this application. Values from 1 to 4.7 ohms may better suit other applications requiring more or less gain.) Capacitors C2 and C3, which help prevent rf detection, are mounted on the foil side of the board using short leads. Shielded audio cable, or even RG-174, should be used for audio connections between the speaker and radio.

how much audio is enough?

This amplifier will drive speakers between 2 and 16 ohms impedance. However, the load impedance sets the maximum audio power. Assuming a 13.8-volt supply, a 4-ohm speaker will allow about 5 watts of audio, while with a 2-ohm speaker the amplifier will deliver nearly 8 watts. Four watts of audio into an efficient speaker system is one heck of a lot of noise; a 4-ohm speaker will do well here.

putting it together

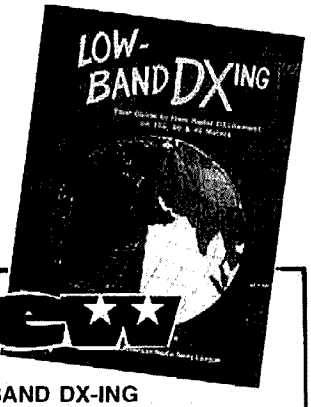
The amplifier is built on a small section of copper-clad PC material. Although this amplifier is intended for audio, a-f ICs will often perform well into the rf frequencies, so good hf practices — a wide, low-impedance ground plane, adequate bypassing, and short leads — must be followed if instability is to be avoided.

Stability is further enhanced by the use of inverse feedback and by the presence of the 0.22-μF capacitor swamping the amplifier output.

To reduce failures caused by mechanical vibration, larger parts, such as electrolytics, may be fastened to the board with a strip of silicone adhesive. The tab of the IC must be heatsunk; either the metal speaker enclosure or a piece of aluminum should be used. Use thermal compound between the LM383 tab and the heatsink.

selecting parts

Don't worry if the exact capacitor values aren't available; considerable leeway is permissible here. But choose the enclosure and speaker carefully. This isn't the place to cut corners. Select a rugged speaker with



new

LOW BAND DX-ING COMPUTER PROGRAMS

by John Devoldere, ON4UN, for Apple IIe/c, MS-DOS, Commodore C-128 Apple Macintosh and Kaypro CPM Computers

Here's a collection of 30 super programs written by ON4UN. Just about every interest or need is covered—from antenna design and optimization to general operating programs. Antenna programs include: shunt and series input L network design, feedline transformer, shunt network design, SWR calculation, plus 11 more! General Ham programs include: sunrise/sunset, great circle distances, grayline, vertical antenna design program, sunrise calendar plus 9 more! Phew. When you sit down to use these programs you'll be amazed at what you have. The best value in computer software available today. © 1986.

☐UN-Apple IIe/IIc	$39.95 ea.
☐UN-MS (MS-DOS)	$39.95 ea.
☐UN-CPM/Kaypro	$39.95 ea.
☐UN-C-128 (COMMODORE)	$39.95 ea.
☐UN-MAC (MACINTOSH)	$49.95

LOW BAND DX'ING
by John Devoldere ON4UN

Now Available! The new, 2nd edition of the definitive book on Low Band DX'ing. Based upon years of practical on-the-air experience, learn the secrets of how ON4UN has been so successful on the low bands. Extensive coverage is given to transmit and receive antennas with clear concise explanations and plenty of illustrations—dipoles, inverted V's, slopers, phased arrays and Beverages—they're all in this book. Also covered: propagation, transmitters, receivers, operating, software and an extensive Low Band bibliography. Going to be a best seller! Get yours today. © 1987 2nd Edition 200 pages

☐AR-UN Softbound $9.95

BUY'EM BOTH SPECIAL OFFER

Book & Software Reg. $49.90 ($59.90 for Mac)

Just $44.90 ($54.90 for Mac)

☐UN-SO (specify computer) $44.90
☐UN-MSO Macintosh Special $54.90

SAVE $5

Please enclose $3.50 shipping & handling

ham radio BOOKSTORE

GREENVILLE, NH 03048 603-878-1441

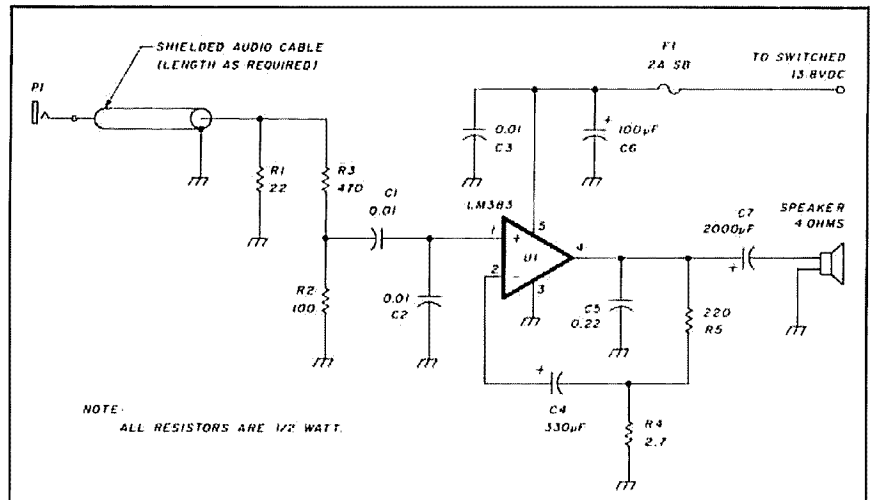


fig. 1. LM383 amplifier schematic.

a stiff cone and a large magnet. The enclosure can be a home-crafted affair, as long as it's structurally sound and free of rattles.

A good source of speakers and companion enclosures is mobile-radio repair shops or dealers who are willing to sell directly to Amateurs. They often have used speakers for sale at reasonable prices. You may have to select an off-brand if the dealer's selection is limited; their priority is to sell accessories as complete packages from inventory. Speakers available from mobile-radio dealers and repair shops are generally of better quality than the general-replacement lines sold by radio and TV repair shops. Be sure to check out your purchase in advance. Years of on-the-job wear and tear take their toll: watch for torn or otherwise damaged cones. Auto-sound stores also carry suitable speakers and matching enclosures.

I mounted the amplifier assembly inside the speaker enclosure. This is largely a personal choice; a separate box housing the amplifier will do as well. My unit is built around an early Motorola mobile speaker. Although its dated styling and large size led to its premature retirement from commercial service, its robust and roomy steel enclosure was well suited for this project.

installation

Once the amplifier is built and tested (and, I hope, working) it's time to install it in the vehicle. Mount the speaker in a clear, unobstructed spot from which the audio can be directed at the driver. Power may be taken from the fuse block; look for a point labeled "accessory" or "ignition." Usually a female or male spade connector is needed to make the power connection. Most automotive stores carry an assortment of these crimp-on connectors. Be sure to fuse the power lead near the power take-off point. Some cars may not have points available to take the power off the fuse block. For these rare instances it's possible to purchase special "piggy-back" connectors that allow additional connections to be made to existing fuses. If alternator whine or other automotive electrical noise is objectionable, try taking power from a different point. Going directly to the battery often works well, but then a power switch will be needed on the speaker. A brute-force filter, consisting of a choke and filter capacitor, is available from Radio Shack.

I hope this speaker will increase your mobile operating pleasure as much as it has mine.

ham radio

locator field list

Do you like challenges? If the widespread acceptance of the DXCC, WAZ, and sundry other operating awards proudly displayed by Amateurs throughout the world is any indication, I'm sure you do.

Folke Rosvall, SM5AGM, has taken it upon himself to compile, on a per-band basis, the total number of fields worked by individuals. His list appears in *ham radio* four times a year (see page 75 of the July issue for the first list published in these pages).

"But," you ask, "What's a field?" Glad you asked. According to the Maidenhead locator system, the world is divided into 324 fields or areas, each 20 degrees wide in longitude and 10 degrees wide in latitude. Though most encompass land masses, quite a few do not; this means no countries, no islands, no reefs—just water. So even if you've worked every country in the world and your name is at the top of the honor roll, you still probably haven't worked all the fields. For example, I'm very active on 80 meters, yet I've been able to snag only 148 out of 324 fields. I can think of a number of other 80-meter operators who are even more active than I am.

Have I tickled you competitive spirit? Think of the ultimate challenge: *work all fields on all 19 bands on one specific mode*. Some quick calculating shows that to be...uh...6156 contacts. That'll keep you off the streets (but probably get you into trouble with your family, your employer, etc.). Seriously, it's all for fun, and you'll learn a little more geography in the process.

All the necessary details are included on the accompanying chart. Folke would be very glad to hear from you. Please send your tabulations directly to him (his address at the bottom of the chart)—not to *ham radio*.

See you on 80!

Rich Rosen, K2RR

LOCATOR FIELD LIST

1987-09-30, COMPILED BY SM5AGM (JO99DK). WHO WILL BE THE FIRST RADIO AMATEUR TO WORK ALL 324 FIELDS ON THE SAME BAND?

AJ / AI	BJ / BI	CJ / CI	DJ / DI												OJ / OI	PJ / PI	QJ / QI	RJ / RI
1.8 MHZ	1 W1JR 2 SM3CWE	FN JP	70 870920 54 870630	3 SM6CTQ 4 OK1DKS	JO JO	33 850127 11 870929	5 SM0LH 6 SM4JXG	JO JO	5 860322 3 861231	7 SM0NZB 8 SK6AW	JO JO	2 870630 1 870630						
3.5 MHZ	1 K2RR 2 SM3CWE 3 W1JR	FN JP FN	160 870923 130 870630 102 870920	4 SM0CCE 5 SM7WT 6 SM0HTO	JO JO JO	79 850122 68 850129 64 851230	7 SK6AW 8 SM5CAK 9 SM6INC	JO JO JO	58 870630 56 860921 29 870630	10 OK1DKS 11 SM3CVM 12 KC9RG	JO JP EN	24 870929 23 870930 10 870630	13 SM0LH 14 SM4JXG	JO JO	8 860322 7 861231			
7 MHZ	1 SM3CWE 2 SM0CCE 3 W1JR 4 SM7WT	JP JO FN JO	142 870630 138 850122 119 870920 97 850129	5 SM7PKK 6 SM6INC 7 SK6AW 8 SM3CVM	JO JO JO JP	86 870322 76 870630 67 870630 59 870930	9 SM0HTO 10 OK1DKS 11 SM0LH 12 9V1RH	JO JO JO OJ	47 851230 21 870929 15 860209 14 870610	13 SM5CAK SM4JXG KC9RG 16 SM0NZB	JO JO EN JO	11 860921 11 861231 11 870630 5 870630						
10 MHZ	1 W1JR 2 9M2FP 3 SM6INC	FN OJ JO	43 870920 31 861220 23 870630	4 SM5FUG 5 SM5ACQ 6 SM3CWE	JO JO JP	21 860912 17 870625 13 870630	7 SM6MSG 8 SM0LH SM4JXG	JO JO JO	10 850930 9 860322 9 881231	10 SM0HTO 11 SM7BDB 12 SM5PAX	JO JO JO	7 851230 5 850922 4 850930	13 SM5CAK SM0NZB 15 KC9RG	JO JO EN	3 860921 3 870630 1 870630			
14 MHZ	1 SM3CWE 2 SM7WT 3 SM0HTO W1JR	JP JO JO FN	222 870630 201 850331 192 851231 192 870920	5 SM0CCE 6 SK6AW 7 W6DU 8 SM6INC	JO JO CM JO	186 850122 157 870630 147 860526 131 870630	9 SM5ACQ 10 OK1DKS 11 SM5CAK 12 SM0LH	JO JO JO JO	122 850930 90 870929 73 860921 57 860212	13 SM3CVM 14 SM5FBL 15 KC9RG 16 SM4JXG	JP JO EN JO	50 870930 44 850126 40 870630 37 861231						
18 MHZ	1 SM6INC 2 SM5ACQ	JO JO	18 870630 12 870331	3 SM7BDB 4 SM4JXG	JO JO	8 850922 7 861231	5 SM0LH 6 SM5PAX	JO JO	5 860322 3 850930	SM0HTO 8 SM3CWE	JO JP	3 851230 2 870630	9 9V1RH	OJ	1 870610			
21 MHZ	1 SM3CWE 2 SM0CCE 3 SM7WT	JP JO JO	158 870630 153 850122 131 850129	4 SK6AW 5 SM6INC 6 SM5DUT	JO JO JO	116 870630 109 870630 97 870910	7 SM5ACQ 8 OK1DKS 9 SM0HTO	JO JO JO	95 850930 72 870929 52 851230	10 SM0LH 11 SM4JXG 12 SM3CVM	JO JO JP	44 860209 38 861231 31 870930	13 KC9RG 14 W1JR 15 SM5CAK	EN FN JO	26 870630 17 870920 10 860921			
24 MHZ	1 W1JR 2 SM7AST/CT1 3 SM6INC	FN IM JO	27 870920 15 870911 12 870630	4 SM0HTO SM4JXG SM5ACQ	JO JO JO	5 851230 5 861231 5 870508	7 KC9RG 8 SM7BDB 9 SM0LH	EN JO JO	3 870630 2 850922 1 860209	9V1RH SM3CWE	OJ JP	1 870610 1 870630						
28 MHZ	1 DF2NJ 2 SM6LIF 3 SM0HTO 4 SM7LXV	JO JO JO JO	159 851111 143 850909 139 851230 127 850630	5 SM0CCE 6 SM3CWE 7 SM6INC 8 SM7WT	JO JP JO JO	126 850122 123 870630 111 870630 108 850129	9 SM0HJV 10 SK6AW 11 SM5DUT 12 SM5ACQ	JO JO JO JO	93 860917 90 870630 69 870910 53 850930	13 SM0LH 14 W1JR 15 OK1DKS 16 SM0JXA	JO FN JO JO	32 860212 29 870920 22 870929 21 861101	17 KC9RG 18 SM4JXG 19 SM5CAK 20 SM3CVM	EN JO JO JP	17 870630 12 861231 9 860921 7 870830			
50 MHZ	1 WA1OUB 2 N0LL W1JR	FN EM FN	46 860801 41 861106 41 870920	4 K0TLM 5 W3WFM 6 KA9MGR	EM FM EN	40 870614 33 870901 16 860331	7 W6RXQ 8 KI3W 9 N9FDS	CM FN EN	15 870630 14 870630 12 870928	10 JQ1GTC KC9RG	QM EN	5 861212 5 870630						
144 MHZ	1 SM7BAE 2 VE7BQH 3 DL8DAT 4 K1WHS	JO CN JO FN	45 870214 42 870113 41 870620 38 840930	5 SM2GGF 6 Y22ME 7 YU3WV 8 SM4GVF	KP JO JN JO	37 850622 36 861231 35 870331 34 860930	9 YU3ZV WA1JXN F6CJG 12 F6BSJ	JN DN JN JN	32 831231 32 840606 32 850110 31 840903	OZ1EME 14 SM4IVE WA4NJP HB9CRQ	JO JO EM JN	31 841224 30 840609 30 840903 30 870818	17 K8ZQ 18 OH7PI W5UN KD8SI	DN KP DM EM	29 851231 28 831231 28 840428 28 850116			
220 MHZ	1 W1JR	FN	10 870920	2 KA9MGR	EN	4 860331	3 W6RXQ	CM	3 870630									
432 MHZ	1 K2UYH DL9KR 3 YU1AW W1JR	FN JO KN FN	33 850331 33 861001 30 860407 30 870920	5 WB5LUA OK1KIR 7 W7GBI 8 SM3AKW	EM JN DM JP	28 840428 28 870623 27 840505 26 861231	9 VE4MA 10 SM6CKU SO1MN 12 OH6NU	EN JO JO KP	23 830331 21 821231 21 860617 20 821231	13 K1FO Y22ME 15 SM0DJW 16 HB9CRQ	FN JO JO JN	19 850318 19 861231 18 851231 13 870818	17 W7HAH 18 DF9CY 19 OZ3ZW SM6FYU	DN JO JO JO	12 860314 10 830627 7 850630 7 860331			
902 MHZ	1 W1JR	FN	2 870920															
1.3 GHZ	1 K2UYH 2 OK1KIR 3 OE9XXI 4 WB5LUA	FN JN JN EM	20 850331 18 870623 16 850331 13 840428	W7GBI 5 SM6CKU 7 YU1AW 8 W6YFK	DM JO KN CM	13 840505 12 821231 11 860407 7 840506	OE9FKI OZ3ZW 11 OL7YC 12 SM6HYG	JN JO JO JO	7 850331 7 850630 6 840411 5 821231	SM0DJW SM3AKW 15 SM0PYP SM4AXY	JO JP JO JO	5 851231 5 861231 4 830331 4 831231	HB9CRQ W1JR OK1DKS 20 K1FO	JN FN JO FN	4 870818 4 870920 4 870929 3 850318			
2.3 GHZ	1 W4HHK OE9XXI OK1KIR	EM JN JN	4 850304 4 850331 4 870623	4 SM6HYG W6YFK 6 W1JR	JO CM FN	3 830331 3 840506 2 870920	OK1DKS 8 PA0SSB WB5LUA	JO JO EM	2 870929 1 821231 1 840428	WA4HGN OZ1CFO W6RXQ	EM JO CM	1 840505 1 850826 1 870630						
3.4 GHZ	1 SM6HYG	JO	1 850914															
5.7 GHZ	1 SM6HYG	JO	1 850914	OZ1CFO	JO	1 850930												
10 GHZ	1 SM5QA 2 SM0DJW	JO JO	4 870930 2 850630	YU1AW W6RXQ	KN CM	2 860205 2 870630	W2TTM 6 SM6HYG	FN JO	2 870927 1 850914	SM7ECM W1JR	JO FN	1 860930 1 870920						

This list shows the number of fields worked according to the Maidenhead Locator system. A field is a block of 20° (longitude) × 10° (latitude). Rules: 1. All fields must have been worked via passive reflectors. 2. All stations involved must be on the earth's surface. 3. QSL cards are not required if you are sure that the other station considers the QSO complete. 4. All QSO's must have been worked from points within a circle of 1000 km radius. 5. There is no starting time for contacts to be eligible. A world map showing the 324 fields can be found in "The Radio Amateur's World (Locator) Atlas", that *normally should be available at your national amateur radio society.*

Compiled quarterly since 1982, the list shows the situation on March 31, June 30, September 30 and December 31 at 2400 UT. Please send your info as soon as possible after each date to SM5AGM, Folke Rosvall, Vasterskarsringen 50, S-184 00 Akersberga, Sweden. Tel. 0764-27638.

ham radio TECHNIQUES

Bill Orr W6SAI

the year was 1923 . . .

It **all happened about 65 years ago.** There were only a few thousand Radio Amateurs in the world. Many of them dreamed that they would someday converse across oceans. But though Americans had indeed heard a few European ham signals and hundreds of United States signals had been heard in Europe, it seemed that a two-way transatlantic QSO was virtually impossible.

However, on the night of November 27, 1923, the impossible happened. Leon Deloy, 8AB, of Nice, France worked Fred Schnell, 1MO, and John Reinartz, 1XAM. Four thousand miles of distance had been conquered in just a few hours. As 8AB said to 1MO, "This is a fine day."

I had known John Reinartz for some years. He never tired of telling the thrilling story of that first contact. Deloy, 8AB, worked many American stations after the record-setting QSO, but it wasn't until December 8 of that year that contact was established between u1MO (Kenneth Warner) and g2KF (J. Partridge), and the radio barrier between America and England was broken.

When I asked John why the first QSO was between USA and France rather than the United States and England — especially since 8MO was located on the Mediterranean coast of France, a good 700 miles further from the east coast of the United States than the British hams, who were centered around London — John had no answer, but explained that 8AB was always consistently louder than the British signals. I asked myself whether it was a matter of power, a better antenna, or a better location at 8AB. I thought I'd never know.

a visit to 8AB

The whole story passed from my mind until 1976, when I was living in Monaco and operating 3A0AF. Conditions from Monaco to the United States were spotty. Good openings were possible in the afternoon around 1600 UTC, but propagation was via the long path. That was a beautiful shot — downhill a short distance, then across the Mediterranean to the United States. Signals from California and other west-coast stations were strong and consistent. But working the United States from Monaco, the short path was a different story. Directly behind the principality, the French Alps towered thousands of feet in the air. The short path to the United States was a tough one, and only the stations on the easternmost coast of the United States could be worked. It was very difficult to work into the Midwest.

Observing this problem first-hand, I began to wonder how Leon Deloy had managed to work the Americans with such a robust signal. After all, Nice was only a few miles from Monte Carlo. How had 8AB conquered the French Alps with his primitive radio equipment?

I knew Leon was retired and living in Monaco. After much hesitation, I looked up his number and called him on the telephone. John Reinartz, who had met him years before, had told me that Leon spoke excellent English. So when he answered the phone, I wasn't surprised to find that I had no difficulty explaining who I was and asking if he would consent to a short visit and an interview. Delighted, he invited me over for tea. Since he lived just a few blocks away, I walked to his home, where he greeted me at the door. As we sat sipping tea in his library, lined with books and decorations he had received from the French government for his work in communications, he told me the story of his record-breaking transatlantic radio work.

Hard work, good equipment, good operating technique, and a good antenna were the answer. The year before the great achievement, Leon had visited several prominent stations in the United States, observing their equipment, listening to band conditions carefully, and noting operating habits. He purchased some of the latest radio equipment to take home with him and spoke at length to Reinartz, examining his station carefully. Returning to his home in Nice, he put into practice what he had learned. When his station was assembled, he cabled the ARRL and told them he would transmit on the exceptionally short wavelength of 100 meters during the evening hours, starting on November 25th. The first night he was on the air, he was heard by Amateurs in the United States! Being appraised by cable that his signals were "crossing the pond," he set up a schedule the next night with Schnell and Reinartz, who had just gotten special permission to use the 100-meter wavelength.

8AB's signal was heard again. The



Photo A. "Mr. DX," Leon Deloy, F8AB, at his home in Monte Carlo in 1976.

town of Nice had a 25-cycle power source and the signal from France had a distinctive gargle on it as Leon applied high-voltage ac directly to his transmitter tube. This time, Schnell and Reinartz were ready. In no time at all, the Atlantic barrier was breached!

I had known the story before I met Leon Deloy, but to hear it from him personally was thrilling. I asked him exactly where he had lived in Nice. What was his QTH like? And what about the French Alps that effectively blocked the path? We discussed these things at length, and the day after the conversation I drove the few miles to Nice to the house from which Leon had made his record-breaking QSOs. The address was 54 Boulevard du Mont-Boron. The street was on the ocean side of the Lower Corniche, one of the main boulevards that ran from Monte Carlo to Nice. The home was a large, pleasant house in the French style. It had a small back yard, but the hills rose sharply behind the location, seemingly blocking it from a direct radio path to the United States.

After surveying the location, I drove to the top of the hills behind Nice and looked down on Boulevard du Mont-Boron. Yes, it was possible. The French Alps dropped in height as they approached the valley of the Var river. The coastline curved around and the mountains were to the north of 8AB, but the shot to the northwest — towards North America, that is — was reasonably clear. 8AB's signals must have grazed the edge of the Alps, then had a clean shot up the Var valley.

Although 8AB was no longer active, he still had a keen interest in Amateur Radio. With his permission, I took a photograph of him (**Photo A**), and one of an oil painting of him as a young man in his dapper French military uniform **Photo B**.

What a grand gentleman! Although he expressed hopes of coming to America again, his health prevented such a journey. He later told me that he had bought a shortwave receiver and listened to the ham bands on occasion, marveling at the ease of voice contacts with sideband signals.

When I heard of his passing, it was as if an era had ended. The Americans at the other end of the great contact had passed away earlier. And now Leon Deloy! It was the end of a fabulous era in Amateur Radio. I always regret that I hadn't seen him again in his library, sipping tea, surrounded by his paintings and awards and honors. We will not see the likes of him again.



Photo B. An oil painting made in 1920, hung in the entry hall of his apartment, depicted F8AB at the time he was awarded the Legion of Honor.

To Amateurs who talk across the Atlantic daily, the adventure of 8AB and the American Amateurs may seem like no big deal. But to the Amateurs of yesterday, all of whom operated in the region of 150 to 200 meters, his DX work on 100 meters opened the shortwave spectrum. Shorter was better, and Amateur activity began a downward trek towards the 100- to 80-meter region.

Amateur regulations were vague at the time. The Radio Laws of 1912 were still in effect, and while Amateurs could operate between 200 and 150 meters, they weren't allowed above 200 meters. The waves below 150 — obviously useless — were not strictly regulated. Finally, in July, 1924, after much prodding by the ARRL, the Department of Commerce authorized the issuance of new licenses for Radio Amateurs permitting the use of wavelengths in the vicinity of the present bands, up to 20 meters. A maverick assignment at 5 meters was tossed into the pot, too. Amateurs applying for new licenses could operate in the new short wave bands. The downward march in wavelength began.

10-meter RFI and all that

First, the good news. The sunspot cycle is climbing rapidly and 10 meters is coming back to life. Many newer Amateurs have never experienced this band when it's fully alive. Plenty of DX can be worked with low power, and there's lots of room for pleasant contacts and rag-chewing.

And now the bad news. The second harmonic of a 10-meter transmitter falls right into TV channel 2, the third harmonic falls into TV channel 6, and the fourth harmonic falls into the channels assigned to air-to-ground communications.

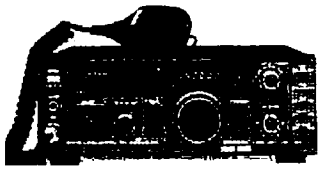
Most Amateurs have no problem with the fourth harmonic, but the second and third harmonics (of even a 100-watt transceiver) can cause problems with nearby television receivers.

In addition, a 10-meter transmitter can overload the input circuits of a nearby TV set, even though the trans-

MADISON SHOPPER

CALL FOR ORDERS
1 (800) 231-3057
1-713-520-7300 OR 1-713-520-0550
TEXAS ORDERS CALL COLLECT
ALL ITEMS ARE GUARANTEED OR SALES PRICE REFUNDED

New Icom IC-761 — Trades wanted
Kenwood TH215A — Trade in your old HT



Kenwood TS140S Call

Kenwood TS-140S	Call for trade
New Kenwood TM-221A, 45W mobile	Call
Lunar 2M4-40P	109.00
ICOM 28H/T1M	399.00



Icom 761	2095.00
Shure 444D	54.95
Astatic MC321 Cartridge D104	12.00
Astatic D104C/TUP-9	72.00
Isopole 144 MHz	44.95
Cushcraft 124-WB (146 MHz)	33.00
Butternut HF6V, 80-10 vertical	125.00
Hustler G7-144	119.95
KLM HF World Class Series Antennas	Call Don
KLM KT-34A	399.00
NEW KLM 144-4BX	129.00
G5-RV	44.00
Avanti AP151-3G on Glass Antenna	36.00
Antenco 2M, 5/8, Mag. Mount, Comp	25.00
Thousands of panel meters	3.95 up CALL
Agovox 1000 pf/500 V feedthrough caps	1.95
100 mfd/450V Axial Cap	2.00
831SP PL259 Silverplate	1.25
82-61 N Male	3.00
GE 6146B	13.95
3-500Z	119.95
GE 12BY7A	7.00
6JE6C/6LQ6	10.95
6KD6	12.95
AEA PK-232 with new WX FAX	299.00
Kantronics KPC II	149.00
New Kantronics KAM	299.00

USED EQUIPMENT
All equipment used, clean with 90 day warranty and 30 day trial. Six months full trade against new equipment. Sale price refunded if not satisfied.
Call for latest used gear
(800) 231-3057
TS-430S, TS-830S, TS-520S, FT101E, and Collins

Porcelain 502 Guy Insulators (1/4)	3.39

POLICIES
Minimum order $10.00. Mastercard, VISA, or C.O.D. All prices FOB Houston except as noted. Prices subject to change without notice. Items subject to prior sale. Call any time to check the status of your order. Texas residents add sales tax. All items full factory warranty plus Madison warranty.

✓ 180

Bird and Belden products in stock. Call today.

MADISON
Electronics Supply
3621 FANNIN
HOUSTON, TEXAS 77004

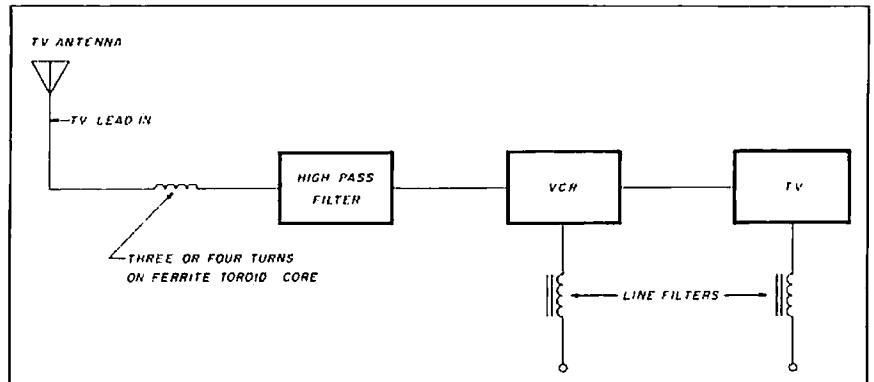


Fig. 1. TVI suppression at the receiver.

mitter may be "clean," as far as harmonic emission goes.

Television interference presents a delicate public relations problem because viewers always assume TVI is the hams' fault and blame them accordingly. In short, TVI isn't a big problem if you don't have it, but it's hell if you do!

Fortunately, many of the TVI problems associated with 10-meter operation can be solved. Your own TV receiver can serve as a guinea pig. If you have no interference problems with it, you might be in good shape with your neighbors. Alas, the ability of TV receivers to reject strong nearby signals varies from manufacturer to manufacturer and from model to model. Your set may be interference-free, but the one next door may not.

where to start

The first step in resolving TVI problems is to place a high-pass filter in the lead-in of the TV set, right at the receiver terminals. Available for either 300-ohm ribbon line or 75-ohm coax, these filters will reject your signals and pass those of the television stations. Unless you're running with a linear, a high-pass filter will knock your fundamental signal down sufficiently to protect the TV receiver.

Your next step is to place a low-pass filter in the coax lead to your antenna. For best results, the filter should be mounted directly on the back of your transmitter and securely grounded to the transmitter ground point. This will substantially reduce any harmonic energy.

You'll find out that when you don't permit the transmitter harmonics to run up your coax to the antenna, they'll seek another avenue of escape. This will be via the interconnecting control leads, the microphone cable, and the power leads of your transmitter.

The next thing to do is wrap the power lead of your transmitter around a ferrite core or rod. Use a high-permeability ferrite*; it will be lossy at 28 MHz and higher frequencies, and any rf current flowing in the lead will be converted into heat in the core material. This simple fix will prevent rf power from flowing into your electrical system.

You can wrap control leads around a smaller ferrite. Either a core or rod

* A suitable ferrite rod around which you can wrap a line cord is the AMIDON R-33-050-750. With a permeability of 800 (33 material), it meaures 7.5 inches long. A longer rod of similar material is the R-33-075-1200, which is 0.75 inches in diameter and 12 inches long — just right for the linear amplifier!

If a ferrite toroid is desired, the AMIDON FT-240-72, 2.4 inches (O.D.) and 1.4 inches (I.D.) is satisfactory. RG-8A/U or RG-59/CU cable can be wrapped loosely around this core, as can 300-ohm ribbon line.

A split core to place over a coax line is the AMIDON 2X-43-151, which is suitable for RG-8A/U coax. Place the two halves of the ferrite over the line and tape them together.

In case of computer interference, AMIDON supplies split bars that fit over flat cables. The 2X-43-951 is for 2-inch wide cable and the 2X-43-051 is for 2.5-inch cable.

These devices are available from AMIDON, 12033 Otsego Street, North Hollywood, California 91607.

will do the job. You may even have to place a ferrite in the microphone lead as close to the mic jack as you can get.

But what if you've done all this and still get TVI on channel 2 when you operate 10 meters?

the final cleanup

As I said, a nearby TV receiver will help you determine the interference relationship between your transmitter and your neighbor's TV set. For my checks, I used the family TV set, which is about 30 feet away from my equipment. The TV antenna is about 40 feet away, and just below it is my 10-meter antenna. Two CB hand-helds provide communication between the transmitter operator and the TV checker. Using these techniques, and running 100 watts, I was completely clean on all channels. But when I turned on my kW linear amplifier, I knocked out channel 2 and cross-hatched channel 6.

All the cures applied to the exciter were then applied to the amplifier: a ferrite choke was placed in the power line, ferrite chokes were installed in the interconnecting leads, and a low-pass filter was added to the coax to the antenna. That made two low-pass filters — one after the exciter and one after the linear amplifier. Channel 6 was now clean, with only mild problems on channel 2.

The last step was placing a ferrite line choke on the TV receiver. The line cord was wrapped around a ferrite toroid, where the power cord left the back of the cabinet. Attention was then directed to the lead-in, which happened to be 300-ohm ribbon.

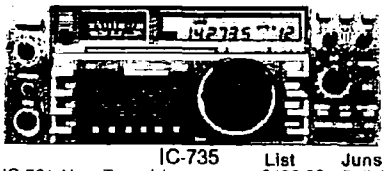
It's possible for the TV lead-in to act as an antenna for hf signals or harmonics. These pass down the lead-in, with the two lead-in wires acting in phase as a common-pickup antenna. The unwanted signal just flows around the high-pass filter with little attenuation. To prevent this, I loosely wrapped the ribbon line through a 2-inch (O.D.) ferrite toroid. I passed three turns through the core and held them in place with a plastic wire-wrap, then placed this little filter just before the high-pass filter as shown in the illustration (**fig. 1**).

All in all, the ferrite filters seem to do a much better job in TVI suppression than do bypass capacitors. They're also much easier to install. (More on interference reduction in a forthcoming column.)

ham radio

800-882-1343

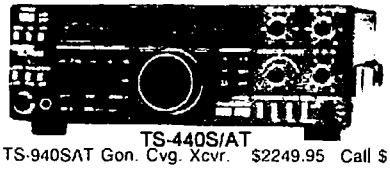
ICOM



IC-735

	List	Juns
IC-761 New Top of Line	2499.00	Call $
IC-735 Gen. Cvg. Xcvr	$999.00	Call $
IC-751A Gen. Cvg. Xcvr	1649.00	Call $
R7000 Gen. Cvg. Rcvr.	1099.00	Call $
R71A Gen. Cvg. Rcvr.	949.00	Call $
IC-28A/H FM Mobile 25w/45w	429/459	Call $
IC-37A FM Mobile 25w	499.00	Call $
IC-900 Super Multi-Band Mobile	589.00	Call $
IC-04AT UHF HT	449.00	Call $
IC-48A UHF 45w	459.00	Call $
IC-38A FM Mobile 25w	459.00	Call $
IC-02AT FM HT	399.00	Call $
IC-μ2AT Micro HT	329.00	Call $

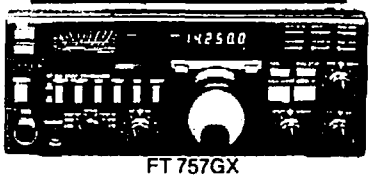
KENWOOD



TS-440S/AT

TS-940S/AT Gen. Cvg. Xcvr.	$2249.95	Call $
TS-430S Gen. Cvg. Xcvr.	819.95	Call $
TS-711A All Mode Base 25w	899.95	Call $
TR-751A All Mode Mobile 25w	599.95	Call $
TS-440S/AT Gen. Cvg. Xcvr	1199.95	Call $
TM-2530A FM Mobile 25w	429.95	Call $
TM-2550A FM Mobile 45w	469.95	Call $
TM-2570A FM Mobile 70w	559.95	Call $
TH-205 AT, NEW 2m HT	259.95	Call $
TH-215A, 2m HT Has It All	349.95	Call $
TH21BT 2M HT	259.95	Call $
TH31BT 220 HT	269.95	Call $
TM-3530A FM 220 MHz 25w	449.95	Call $

YAESU



FT 757GX

FT-757 GX Gen. Cvg. Xcvr.	$995.00	Call $
FT-767 4 Band New	1895.00	Call $
FT-211 RH	459.95	Call $
FT-290R All Mode Portable	579.95	Call $
FT-23 R/TT Mini HT	299.95	Call $
FT-209RH RM Handheld 5w	359.95	Call $
FT-726R All Mode Xcvr	1095.95	Call $
FT-727R 2M/70CM HT	479.95	Call $
FT2700RH 2M/70CM 25w	599.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

Boost the Range of Hand-Helds

Today's hand-held VHF/UHF scanners and handie-talkies from Bearcat, Regency, Cobra, and Radio Shack, ICOM, Yaesu, and Kenwood have excellent sensitivity and talk power, but their range is reduced by their short flex antennas.

Tip: To increase the range of your hand-held scanner or transceiver, connect a Grove ANT-8 extendable whip antenna, equipped with standard BNC base.



By Bob Grove
WA4PYQ

EQUIP-tips

Tips from the expert on boosting the performance of your radio equipment

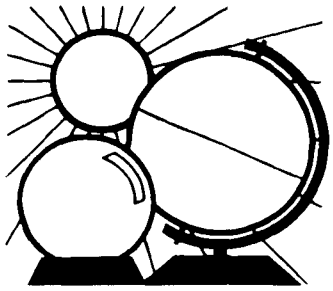
The Grove ANT-8 is a fully-adjustable, professional whip antenna made of chrome-plated brass and equipped with a standard BNC base to fit most hand-held radios. Length is extendable from 7 to 46 inches. Replace that inefficient "rubber duckie" with the ANT-8 and *STAND BACK!*

Only $12.95 plus $1.50 UPS Shipping (US)

Grove Enterprises
140 Dog Branch Road Brasstown, N.C. 28902
(704) 837-9200 or (MC, Visa & COD only) 1-800-438-8155

182

181



DX FORECASTER

Garth Stonehocker, KØRYW

solar cycle update

Enough time has passed to take the guesswork out of determining the sunspot number (SSN) minimum. Since the official value, is, by definition, a 12-month running average, it takes a year's worth of values to define the SSN centered on a date six months ago. The upward SSN trend also takes time to determine: from six months to a year, to be precise. The minimum for Cycle 21 could have occurred in September 1986 at a relatively high value of 12.3, although official international numbers are still being evaluated and things may change a little. This would make Cycle 21's duration equal to 10.25 years, which is closer to the short end of the solar cycle range of 9.0 to 13.6 years.

Scientists at the Space Environment Center (SEC) at Boulder have been reviewing predictions made by several methods to see what Cycle 22's maximum value, and the date of its occurrence, might be. A summary of their findings indicates 145 as the maximum value — a little lower than Cycle 21's maximum. However, the values for Cycle 22 range from 118 to 185. Most of the scientists agree, however, that whatever the maximum might be, it will probably occur in 1990 (i.e., during the period from December 1989 to 1991). These predictions will be refined as the cycle starts its sharp ascent over the next six months.

The solar flux measured at Ottawa, Canada, on 2800 MHz (10.7 cm) indicates a slightly different Cycle 21 minimum than that obtained from sunspot records. The minimum solar flux, a measured quantity, occurred during the period from June 24 to June 30, 1986. This raw data was corrected to one A.U. (Astronomical Unit, or the distance between the sun and the Earth at equinox) in order to extrapolate solar flux values measured at the earth's surface to those which occurred *at the sun*. The corrected minimum (at the sun) occurred in September 1986. However, the ionosphere "recognizes" only the measured values (at the earth's surface), of course. Consequently, the period of the solar flux cycle was from June 1975* to June 1986, for a total length of 11.05 years. The lowest value of daily flux was 66 — a high minimum, indeed. This reinforces the prediction of a lower SSN maximum for Cycle 22. If this is accurate, expect a Cycle 22 SSN between 110 and 125 (160-180 flux), spread over the 1990 to 1992 timeframe. In any case, a rapid rise in flux should be noticed *this* winter. The geomagnetic field will become stable, and recurrent-type geomagnetic disturbances will subside until the 27-day flux peaks reach a value of approximately 150, after which time flares will become more potent and cause more intense geomagnetic disturbances of shorter duration.

We can look forward to more frequent 10- and 12-meter openings by the end of 1988. A steady increase in solar flux is occurring already. This increase is about 3 SSNs, or 2 flux units, per month, which is equivalent to a 0.13 MHz (or 13 percent) increase per month. This will soon increase to 5 SSNs or 3.8 flux units, which is about 0.17 MHz (15 percent) per month for noontime mid-latitude MUFs. Of course the normal 27-day flux variation period of the sun's rotation is superimposed upon this steady increase. Flaring regions of sunspots will augment longer term solar flux values. On a daily basis, if there's only a 2 to 3 flux unit change per day, the MUF will change by one-half percent per flux unit, with no delay. If, however, there is a change of 10 to 20 flux units in a day, the MUF will change by 30 percent of the flux unit (change), with a 2- to 3-day lag. Consequently, it's possible to utilize the solar flux data transmitted by WWV, or available from the computer billboard at SEC, to determine 10- and 12- meter band conditions next year.

* Note: this represents a correction to November 1986 "DX Forecaster" — Ed.

last-minute forecast

The higher frequency bands should be very good the first five days of the month and after the 21st. Look for good transequatorial openings to the southern countries. Openings may be enhanced during geomagnetic disturbances around January 8, 18, and 28. The lower bands are expected to be their best this winter around the 5th

JANUARY

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	4:00	40	40	20	15	15	10	12	20	5:00	40	40	20	15	15	12	12	20	6:00	7:00	40	40	20	20	15	15	15	30
0100	5:00	30	40	20	15	15	12	12	20	6:00	40	40	20	20	15	15	15	20	7:00	8:00	40	40	20	20	20	20	20	40
0200	6:00	30	40	20	20	15	15	15	20	7:00	40	40	20	20	15	15	15	30	8:00	9:00	40	40	30	20	20	20	20	40
0300	7:00	40*	40	20	20	15	15	15	20	8:00	40	40	30	20	20	20	20	30	9:00	10:00	40	40	30	20	20	20	20	40
0400	8:00	40	40	30	20	20	20	20	30	9:00	40	40	30	20	20	20	20	40	10:00	11:00	40	40	30	20	20	20	30	40
0500	9:00	40	40	30	20	20	20	20	40	10:00	40	40	30	20	20	20	20	40	11:00	12:00	40	40	30	20	20	30	30	40
0600	10:00	40	40	30	20	20	20	20	40	11:00	40	40	30	30	20	20	20	40	12:00	1:00	40	40	30	30	20	30	30	40
0700	11:00	40	40	30	30	20	20	20	40	12:00	30	40	30	30	20	20	30	40	1:00	2:00	40	40	30	30	30	30	30	40
0800	12:00	40	40	30	30	20	20	30	40	1:00	30	40	30	30	30	30	30	40	2:00	3:00	40	40	30	30	30	30	30	40
0900	1:00	40	40	30	30	20	30	30	40	2:00	40	40	30	30	30	30	30	40	3:00	4:00	40	40	30	30	30	30	30	40
1000	2:00	40	40	30	30	30	30	30	40	3:00	40	40	30	30	30	30	30	40	4:00	5:00	40	40	15	30	30	30	30	40
1100	3:00	40	40	30	30	30	30	30	40	4:00	40	40	20	30	30	30	30	40	5:00	6:00	30	30	15	20	30	30	30	40
1200	4:00	40	40	30	30	30	30	30	40	5:00	40	30	15	20	30	30	30	40	6:00	7:00	40	20	12	15	30	30	30	40
1300	5:00	40	40	20	20	30	30	30	40	6:00	40	30	15	15	30	30	30	40	7:00	8:00	40	20	12	15	20	20	20	40
1400	6:00	40	30	15	15	30	30	30	40	7:00	40	20	12	15	20	20	20	40	8:00	9:00	40	20	12	15	20	20	20	40
1500	7:00	40	20	15	15	15	20	30	40	8:00	40	20	12	15	15	30*	20	40	9:00	10:00	40	20	10	12	15	20	20	40
1600	8:00	40	20	12	12	15	30	20	40	9:00	40	20	12	12	15	20	20	40	10:00	11:00	40	20	10	12	15	20	20	40
1700	9:00	40	20	12	12	15	20	20	40	10:00	40	20	12	12	15	20	20	40	11:00	12:00	40	20	10	12	15	20	20	40
1800	10:00	40	30	12	12	15	20	20	40	11:00	40	20	10	12	15	20	20	40	12:00	1:00	40	20	12	10	15	15	20	40
1900	11:00	40	40	12	10	15	15	20	40	12:00	40	30	12*	10	15	15	20	40	1:00	2:00	40	30	12	10	15	15	20	40
2000	12:00	40	40	12	10	15	15	20	30	1:00	40	40	12	10	15	15	20	40	2:00	3:00	40	40	12	10	15	15	15	40
2100	1:00	40	40	15	10	15	12	15	20	2:00	40	40	12	12*	15	12	15	30	3:00	4:00	40	40	15	12	15	12	15	30
2200	2:00	40	40	15	12	15	12	15	20	3:00	40	40	15	12	15	12	15	20	4:00	5:00	40	40	20	12	15	12	15	20
2300	3:00	40	40	15	12	15	10	15	20	4:00	40	40	20	12	15	10	15	20	5:00	6:00	40	40	20	12	15	15	15*	30
		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next higher band for possible openings.

through the 8th. However, during disturbances, expect lower MUFs and signal strengths and QSB on the auroral paths — i.e., long east-west and northern routes. Approximately one week later, after the beginning of these disturbances, look out for the winter absorption anomaly to occur, especially from the 18th on (listen for a STRATWARN from WWV).

Lunar perigee will occur on the 8th, with a full moon on the 20th. An intense but short-duration meteor shower, the Quadrantids, will occur between January 2 and 4, and last a few hours.

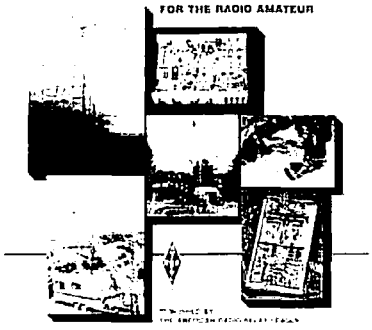
band-by-band summary

Ten, twelve, fifteen, and twenty meters will be open from morning till early evening almost every day and to most areas of the world. The openings on the higher of these bands will be shorter and will occur closer to local noon. Transequatorial propagation on these bands will more likely occur toward evening during conditions of high solar flux and disturbed geomagnetic field conditions.

Thirty and forty meters will be useful almost 24 hours a day. Daytime conditions will resemble those on 20 meters. Skip distances and signal strengths may decrease during midday on days that coincide with these higher solar flux values. Nighttime DX will be good except after days of high MUF conditions and during geomagnetic disturbances. Look for DX from unusual places on east, north, and west paths during this time. The usable distance is expected to be somewhat less than on 20 in the daytime and greater than on 80 at night.

Eighty and one-sixty meters will exhibit short-skip propagation during daylight hours and lengthen for DX at dusk. These bands follow the darkness regions opening to the east just before your sunset, swinging more to the south around midnight, and ending up in the Pacific areas an hour or so before dawn. The 160-meter band opens later and ends earlier than 80.

THE 1988
ARRL
HANDBOOK
FOR THE RADIO AMATEUR



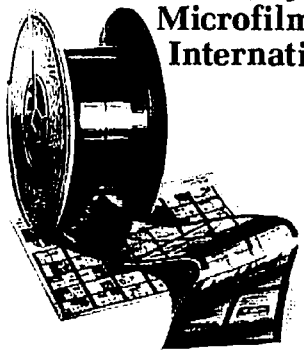
NEW
EDITION

The 1988 ARRL Handbook For The Radio Amateur carries on the tradition of the previous editions by presenting 1200 pages of comprehensive information for the radio amateur, engineer, technician and student. Clothbound only. **$21** in the U.S., **$23** in Canada and elsewhere.

THE AMERICAN RADIO RELAY LEAGUE
225 MAIN STREET
NEWINGTON, CT 06111

185

This publication is available in microform from University Microfilms International.



Please send information about these titles:

Name

Company/Institution

Address

City

State Zip

Phone ( )

Call toll-free 800-521-3044. In Michigan, Alaska and Hawaii call collect 313-761-4700. Or mail inquiry to: University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106.

2x4Z BASE REPEATER ANTENNA

THE HIGHEST GAIN DUAL BAND BASE/REPEATER ANTENNA

HIGH POWER 200 WATTS

CENTER FREQUENCY
146.500 MHz
446.500 MHz

GAIN:
VHF - 8.2dB
UHF - 11.5dB
VSWR - 1.-1.2 or less

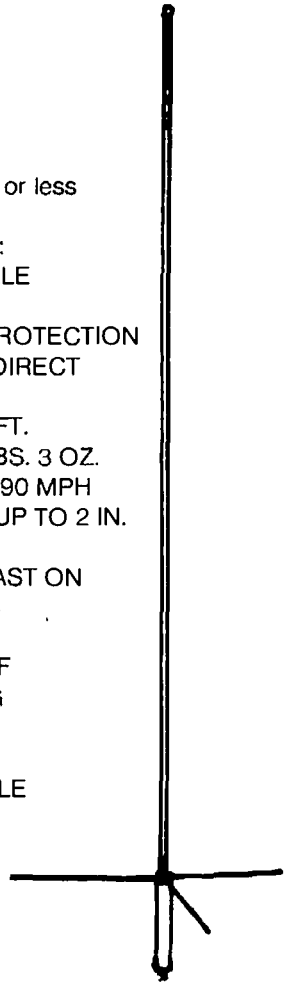
CONNECTOR:
N TYPE FEMALE

LIGHTNING PROTECTION
GROUNDED DIRECT

LENGTH: 16 FT.
WEIGHT: 5 LBS. 3 OZ.
WIND LOAD: 90 MPH
MOUNTING: UP TO 2 IN. MAST
CAN SIMULCAST ON BOTH BANDS

WATERPROOF CONNECTING JOINTS

UPS SHIPPABLE



AMATEUR SPECIAL

NCG CO.
NCG

1275 NORTH GROVE ST.
ANAHEIM, CALIF. 92806
(714) 630-4541
CABLE: NATCOLGLZ
FAX (714) 630-7024

186

ELMER'S NOTEBOOK

Tom McMullen, W1SL

power measurements

The subject for this month's notebook — power measurements — popped into mind while I was writing last month's column. Rather than append a lengthy footnote to that dissertation (on 1200 MHz equipment — see December 1987, page 113), I decided that the topic deserved more thorough treatment.

The trigger word was "PEP," or peak-envelope power. Because power measurements have always been one of the elements of electronics that require some study, I'll use this month's column to explain what they're all about.

dc measurements

There's not a lot that's exciting about dc power measurements, or about measuring equipment, for that matter. But it helps to know something about them so you'll have some basis for what's to follow.

You can learn all you need to know about dc with the aid of a voltmeter, an ammeter, and a couple of simple formulas. It's all very straightforward: voltage times current equals power (E x I = P). If you don't have an ammeter, you can measure the voltage drop across a resistor and obtain the power by using the formula $P = E^2/R$. If you use an oscilloscope to look at a dc waveform, you'll see a straight line across the screen, at a level that's displaced from the zero-voltage line of the trace (see **fig. 1A**). By carefully calibrating the oscilloscope screen, you can read the voltage with precision. With dc, what you see is what you get — the peak voltage and average voltage are the same.

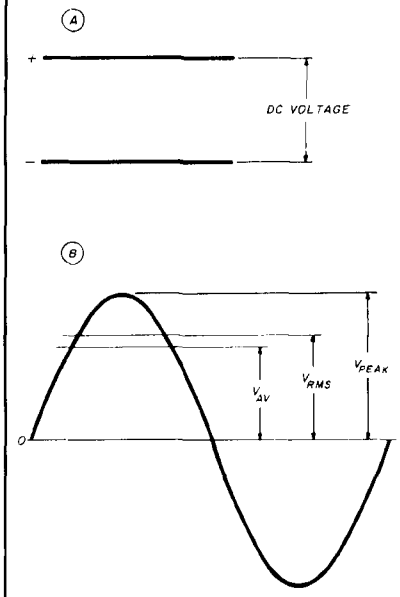


fig. 1. DC and AC waveforms require different measuring techniques. A voltmeter will show the correct reading of dc, as at a. To read the exact value of an ac wave, as at b, an oscilloscope is useful. A dc meter with diode rectifiers will generally read the average voltage, although some are calibrated to provide RMS readings.

ac measurements

When you turn your efforts to measuring ac voltages, things get more complex. The meter you used for dc is no longer useful. If you connect the probes from a dc voltmeter across a source of ac, you might see no pointer movement at all, or perhaps just a blur as the pointer tries to keep up with the rapidly changing waveform. The common way to obtain an ac-reading voltmeter is to insert a rectifier diode in series with one lead (or sometimes a bridge rectifier, which will provide a higher resultant dc reading on the meter). This type of meter provides a reading that generally represents the average voltage of the ac waveform, shown in **fig. 1B**, although some read RMS and are marked accordingly on their scales.

An oscilloscope will show you the true value of the ac waveform, including the negative-going and positive-going peaks. With a calibrated oscilloscope, you can measure the peak voltage accurately.

The average voltage (of a rectified sine wave) bears a direct relationship to the peak voltage by the formula $V_{av} = 0.637 \times V_{peak}$.* Knowing this relationship, you can turn the formula around to use the average reading (from a voltmeter with a rectifier) as a means of finding the peak voltage: $V_{peak} = 1.571 \times V_{av}$.

Though this relationship of average to peak holds true for any undistorted sinusoidal waveform, a distorted waveform doesn't follow the same rules.

* Note that this value isn't the same as the RMS voltage, which is obtained by $V_{RMS} = 0.707 \times V_{peak}$, and $V_{peak} = 1.414 \times V_{RMS}$.

THE RF CONNECTION

"SPECIALIST IN RF CONNECTORS AND COAX"

Part No.	Description	Price
321-11064-3	BNC 2 PST 28 volt coaxial relay, Amphenol Insertion loss: 0 to 0.75GHz, 0.10dB Power rating: 0 to 0.5GHz, 100 watts CW, 2 kw peak Isolation: 0.1 GHz/45db, 0.2 GHz/ 40db, 0.4 GHz/35db	$25 used tested
83-822	PL-259 Teflon Amphenol	1 45
PL-259 ST	UHF Male Silver Teflon, USA	1 30
UG-21D/U	N Male RG-8, 213, 214, Amphenol	7 95
UG-21B/U	N Male RG-8, 213, 214, Kings	3 75
9913-PIN	N Male Pin for 9913, 9086, 8214 fits UG-21D/U & UG-21B/U N's	1 50
UG-21D/9913	N Male for RG-8 with 9913 Pin	3 95
UG-21B/9913	N Male for RG-8 with 9913 Pin	4 75
UG-146/U	N Male to SO-239, Teflon USA	5 00
UG-83/U	Female to SO-239, Teflon USA	5 00

"THIS LIST REPRESENTS ONLY A FRACTION OF OUR HUGE INVENTORY"

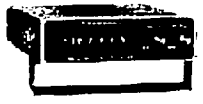
THE R.F. CONNECTION
213 North Frederick Ave. #11
Gaithersburg, MD 20877

(301) 840-5477

CASH PRICES

191

SYNTHESIZED SIGNAL GENERATOR



MADE IN USA

MODEL SG-100F $429.95 delivered

- Covers 100 MHz to 199.999 MHz in 1 kHz steps with thumbwheel dial • Accuracy +/– 1 part per 10 million at all frequencies • Internal FM adjustable from 0 to 100 kHz at a 1 kHz rate • External FM input accepts tones or voice • Spurs and noise at least 60 dB below carrier • Output adjustable from 5-500 mV at 50 Ohms • Operates on 12 Vdc @ ½ Amp • Available for immediate delivery • $429.95 delivered • Add-on accessories available to extend freq range, add infinite resolution, AM, and a precision 120 dB attenuator • Call or write for details • Phone in your order for fast COD shipment.

VANGUARD LABS
196-23 Jamaica Ave., Hollis, NY 11423
Phone: (718) 468-2720 Mon. thru Thu.

192

ALL BAND TRAP "SLOPER" ANTENNAS!



FULL COVERAGE! ALL BANDS! AUTOMATIC SELECTION with PROVEN Weatherproof sealed Traps - 18 Ga Copperweld Wire! GROUND MOUNT SLOPERS - No Radials needed! Ground to rod...or house water faucet! Connect Top to Trees, Buildings, Poles, etc at ANY angle from Straightup to 60 degrees for excellent "SLOPER" DX Antenna Gain or band it anywhere you need to! 2000 Watt PEP Input, max. Permanent or portable Use Installs in 10 minutes. SMALL - NEAT - ALMOST INVISABLE - No one will know you have a Hi-Power DX Antenna. Ideal For COND'Os APARTMENTS- RESTRICTED AREAS - Pre-tuned for 2-1 or less SWR over ALL bands (except 80-160-300khz) No adjustments needed - EVER. COMPLETELY ASSEMBLED, with 50 ft RG-58U Coax feedline and PL259 connector - Built in lightno arrestor - ready to hookup! FULL INSTRUCTIONS!

No. 1080S—80-40-20-15-10—1 trap 49 ft.—$59.95
No. 1040S — 40-20-15-10 — 1 trap 25 ft.—$56.95
No. 1020S——20-15-10 ——1 trap 13 ft. ——$57.95
No. 1016S—160-80-40-20-15-10—2 traps 93 ft. — $89.95

SEND FULL PRICE FOR PP OEL IN USA (Canada is $5.00 extra for postage etc) or order using VISA, MASCARO - AMER EXP. Give Number Ex Date. Ph 1-308-236-5333 weekdays. We ship in 2-3 days (Per Cks 14 days) Guaranteed 1 yr - 10 day money back trial.

WESTERN ELECTRONICS
Dept. AH Kearney, Nebraska 68847

193

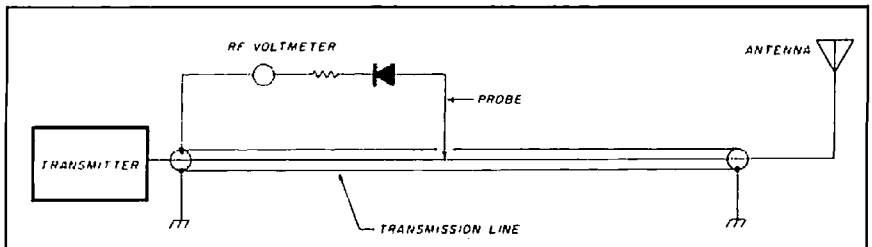


fig. 2. An rf voltmeter, shown here in simplified form, can be used to measure voltage on the transmission line. The line must be properly terminated, see text.

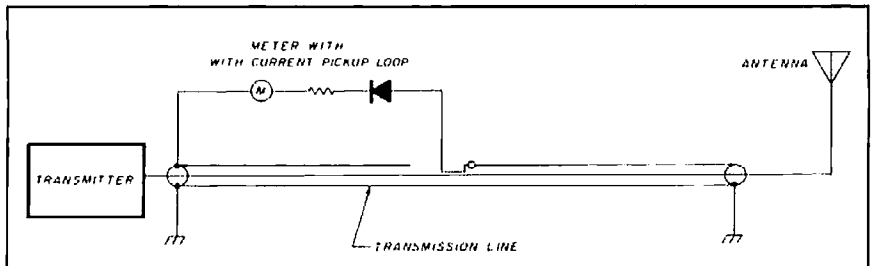


fig. 3. A pick-up loop will sample current flowing in a transmission line and provide a relative meter reading.

rf meters

Meters that measure RF are basically the same as those used to measure lower-frequency ac; a dc meter with diode(s) will provide a reading that represents some percentage of the waveform that's applied to it. The percentage for RF won't be the same as for lower-frequency ac such as 60 Hz, however. Variables such as the efficiency of the diode, the amount of resistance and capacitance in the meter/diode circuit, and the frequency of the RF being measured will all affect the reading.

You can check RF output power by measuring the voltage across a known resistor. The "known resistor" can be your 50- or 75-ohm transmission line (**fig. 2**). The formula is $P = E^2/R$, where R is the impedance of the transmission line. If the diode/meter combination is accurately calibrated, the results of such measurements are reliable.

Another common method of checking RF output power is to use a coupling loop inserted in the field of a transmission line. The loop samples the current flowing in the line, and can be thought of as a transformer working at radio frequencies. The RF energy picked up by the loop is passed through a diode and applied to a meter (**fig. 3**). The Bird (or similar) type of in-line wattmeter uses this technique.

For either of these methods, the meter and pickup circuitry must be calibrated and used in a properly terminated transmission line.

PEP

After that review of measurement techniques and instruments, let's look at some applications, such as measuring PEP. We all know that PEP stands for peak envelope power. But what's an *envelope*?

To follow this, look at **fig. 4**. If you have access to an oscilloscope and a signal generator with built-in modulation, you can see a waveform like this by connecting the output of the generator to the input of the 'scope, and then turning on the modulation. By experimenting a bit with the scan rate of

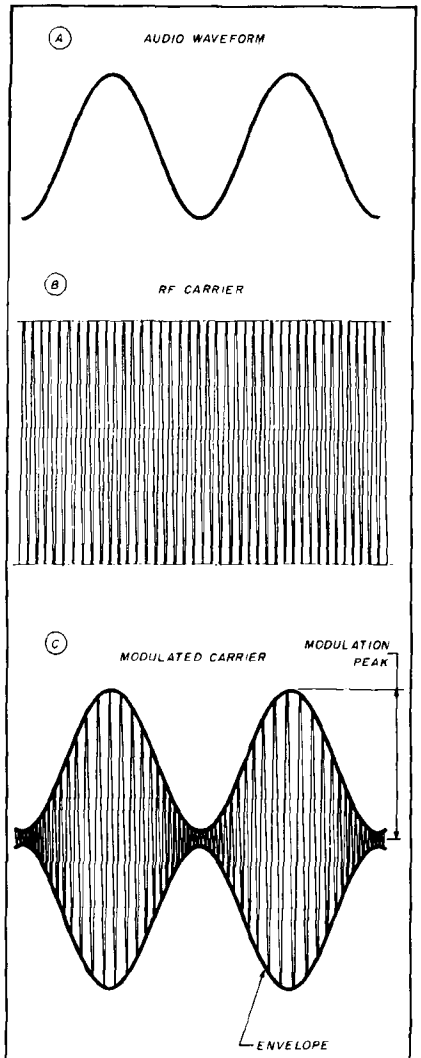


fig. 4. Amplitude modulation (A-M) waveforms. At a, the audio waveform; at b, the rf carrier; and at c, the modulated carrier.

the 'scope trace and with the level settings of the generator, you can produce a picture that appears very much like that which is shown in **fig. 4C**.

The modulation shown in **fig. 4A** and the RF carrier displayed in **fig. 4B** combine to produce the modulated carrier shown in **fig. 4C**. You'll note that the larger waveform (the modulation) has what appears to be a mirror image of itself, with some parts that almost touch at the center of the vertical screen trace. If you increase the modulation level enough, these parts that touch will become flattened. This is *overmodulation*; if it's done on the air, it will cause splatter that will interfere with other stations.

Inside the larger waveform are sweep traces that are of a much higher frequency. This is the RF carrier. It follows the modulation to its highest peaks and decreases to practically nothing on the negative-going parts of the waveform. The larger waveform with the RF carrier inside it is called the *modulation envelope*. That's where the "envelope" part of PEP comes from, and the peak power is measured (or calculated) by using the voltage measured from the reference (zero) line to the tip of the modulation peak.

Here's another bit of theory applicable to a-m transmitters: because every positive-going modulation peak is matched by a negative-going one, the average power input is always the same. Because of *that*, the plate current to the final amplifier doesn't vary. (If it does, there's something wrong — perhaps low RF drive, incorrect bias, a power supply that has a poor output filter, a weak p-a tube, etc.) This is true for both voice-modulation and sine-wave modulation because voice waveforms have positive- and negative-going peaks too. Your antenna (or feedline) current will, however, increase with modulation peaks because the output contains sidebands that add their power to the carrier.

the SSB problem

Single-sideband voice transmission doesn't provide a steady RF-carrier output or a steady p-a power input that can be easily measured by common meters. A p-a plate-current meter will attempt to follow the modulation peaks when you speak, but because of the slow response time of the meter pointer, it will never quite catch up.* When you apply a steady tone (a test signal), the meter will show a steady value that's useful for tune-up purposes, but voice modulation will produce a meter reading that's only a fraction of that value. The ratio is very unpredictable; each person's voice has

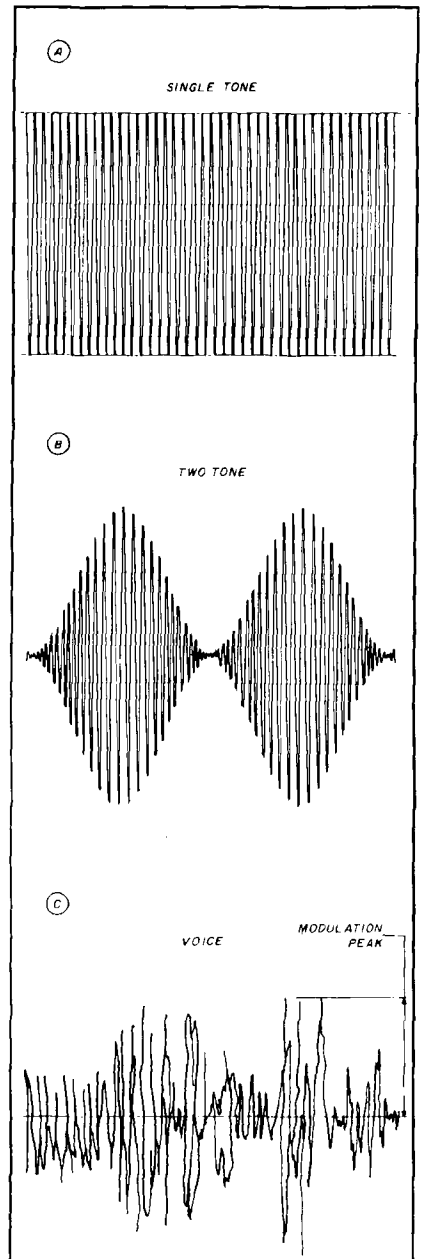


fig. 5. SSB transmitter output waveforms. Shown at a is a single-tone output, which is a steady carrier. At b is a two-tone test signal, and c shows voice modulation.

* This lag in response time in meter movements is called *inertia*, and is created by the mass of the pointer and any parts, such as the moving coil (armature), attached to it. The reluctance of the coil moving in a magnetic field also affects the inertia of the meter. External circuitry, such as a very low resistance across the meter terminals can also slow the response time of the meter, but this is called *damping*.

different peak-to-valley characteristics and different frequency content, and not all meters respond the same way. The meter reading for voice could be as low as 25 to 30 percent of that for steady-carrier conditions, for equivalent peak power.

Figure 5A shows a typical SSB output waveform with a steady one-tone test signal, and **fig. 5B** shows the output for a two-tone test signal. **Figure 5C** shows a voice-modulated SSB signal.

An oscilloscope can be used to monitor a voice-modulated SSB signal, and the peak voltage reading noted and used to compute the power at that instant. Oscilloscopes haven't found great favor among the Amateur community, however. Many of them are larger than the other components of the station, and most have an appearance more appropriate to a laboratory setting than an operating position.

Some manufacturers such as Heath, Kenwood, and Icom have produced "station monitors" designed to fit neatly into an equipment lineup. These dressed-up oscilloscopes will show the audio peaks and valleys, and if calibrated for the transmission line and frequency of operation, will provide a reliable means of checking peak power output.

There are RF-output meters that provide peak readings. Some are manufactured by the major suppliers of Amateur transceivers, and provide a choice of either RMS or peak reading. I've seen Bird wattmeters advertised as "peak reading," and there may be others I'm not aware of.

For you builders, there's a digital PEP wattmeter described in Chapter 34 of the ARRL's 1987 *Radio Amateur's Handbook*. It uses peak-detectors to sample the voltage on a transmission line, and a holding circuit to hold the value long enough for the digital readout to provide an indication.

The thing to remember about any meter that samples either the current or voltage in a transmission line is that they're accurate only if the feedline is properly matched. If you use 50-ohm coaxial cable, but your antenna appears as 30 ohms, the SWR will quite thoroughly mess things up so that the readings you get are meaningless. (This brings up the subject of SWR and VSWR, which I'll cover in next month's column).

which measurement?

So what does the FCC want you to measure? There's a "grandfather clause" in the regulations that permits General-class and higher licensees to use p-a plate input power as a measurement until 1990 — with a limit of 1000 watts.

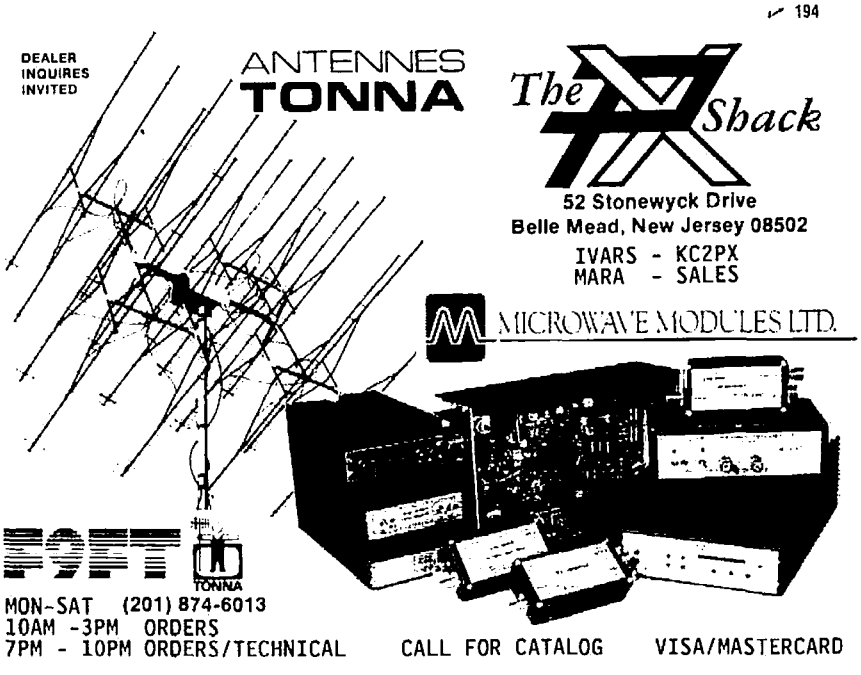
Otherwise, all Amateur power levels are stated as PEP output, with a maximum for General-class and higher of 1500 watts.* (Note: when a higher-class licensee is operating in the Novice segment of any band, the higher-class licensee must observe the same power limits as the Novice).

Novices are allowed 200 watts PEP output on their segments of the 80, 40, 15, and 10-meter bands. On 220 MHz, the limit is 25 watts PEP output. On 1270 MHz, it's 5 watts.

You already have a yardstick that ignores the usually poor efficiency of the transmitter. With tube-type transmitters, efficiency depends upon correct drive, age of the tube, how hot the filament (or cathode) is, the *Q* of the output circuit, and how well the circuit is adjusted, among other things. All of these variables combine to make the actual output a rather uncertain figure. With solid-state transmitters, efficiency is often poor to begin with, and it changes with applied voltage as well as circuit adjustment, matching to the load, and even operating temperature. So, although it's not as easy to obtain as p-a input, PEP output is a more universally "fair" measurement.

In case your transceiver has an internal RF power metering circuit (and many solid-state units do have such circuits), it can be used for a-m, CW, or fm after being properly calibrated by checking against a decent-quality output wattmeter and dummy load. For SSB, this type of meter won't provide an accurate indication of PEP output unless the manufacturer has specifically designed it to do so.

* Except on the 30 meter band, where the limit is 200 watts PEP output.





KPC-4 packet TNC

The Kantronics KPC-4 Packet TNC features dual 1200 baud ports allowing simultaneous connections and conversations through each port. This TNC is excellent for VHF to HF gateway operations, packet bulletin board connections through different VHF frequqncies or bands, and also VHF to VHF gateways. 2400 baud operation is possible on port 2 with the additon of the Kantronics 2400 Modem. Independent watchdog timers on each TNC port and a unique power brownout supervisory circuit permit unattended digipeater service. Operating parameters are retained via a 512 byte EEPROM eliminating the need for battery backup. Mobile, digipeater or portable operation is enchanced by the low-current single 12-VDC power supply requirements for the KPC-4. Home station power for the TNC is supplied by a wallplug type powerpack.

The KPC-4 includes the Kantronics Personal Mailbox feature. This remarkable mailbox was reviewed in detail in the October 1987 issue of Ham Radio. The mailbox operation is transparent — that is the TNC is still fully usable for digipeating, gateways or carrying on a packet QSO while the mailbox is being used. The operator may access the mailbox while the TNC is in a connected state. The KPC-4 has 32K of RAM, expandable to 64K, as compared to the 16K supplied with the earlier versions of the KPC-2, greatly increasing the mailbox capacity. The mailbox is not intended to serve a large user base — it is, as its name implies, a personal type mailbox intended to receive and store messages to and from the TNC's owner. But certainly some limited club applications are possible, such as posting meeting notices or similar limited-size general information bulletins. The mailbox is capable of receiving autoforwarding messages from its files. The command structure is basically the same as for the KPC-2 TNC using the mailbox firmware, except for several new commands for controlling the dual-port feature and gateway functions. The manual is nearly 90 pages long with in-depth coverage of the packet commands and parameters used by the KPC-4.

Nine LED front panel indicators continuously monitor TNC operations. The MAIL LED lights when a station is connected to the PBBS, or plinks continuously to indicate when mail addressed to you is present. Two LEDs indicate transmitter ptt keying for each port, two others indicate when either port is receiving data. The RPT LED indicates when gateway or digipeater functions are actively in use. Unacknowledged packets cause the STA LED to illuminate. The remaining LED is the power indicator.

The KPC-4 will easily interface with most popular computers. All that is needed is a simple modem program to allow communications between the TNC and computer. The computer port uses true RS-232 levels for interfacing, or alternatively the levels may be converted to TTL by simply moving a jumper — permitting use with the popular Commodore 64 computers. For those few modem programs that use it, the KPC-4 supports TRS/CTS handshaking. The AFSK levels to the radio transmitter may be set at 10-mV or 50-mV via an internal jumper; or, alternatively, by changing internal resistors audio levels up to 1 volt are possible. Prewired cable assemblies are supplied for both radio ports and for the computer port — no connector is supplied for the computer end of the cable. The manual provides detailed information and examples for interfacing the KPC-4 with your computer and radio.

Since the KPC-4 is capable of operating as a fully automatic independent gateway you can provide access for your local VHF/UHF area network to a mailbox or gateway system. Two principle commands control gateway operations — MYGate and Gateway. MYGate is used to program the gateway identification; this call must be different than that used for MYcall or MYAlias. This is easily done by changing the ssid extender, for example if K1ZJH were used for MYcall, K1ZJH-1 would serve for MYGate. The Gateway command is used to turn the gateway off or on from the computer keyboard. When this command is on, packets addressed through the KPC-4 digipeater from either port will be automatically transmitted through the other port and visa-versa. Obvious uses would include cross-connecting area LANS operating on different frequencies and/or bands, multiple band and/or frequency operation for a packet PBBS, or for providing secular non-Amateur "wormhole" communication paths between distant LANS.

As with the other Kantronics products I've owned and used the KPC-4 uses highgrade components and is solidly built. For more information contact Kantronics, Inc., 1202 East 23rd Street, Lawrence, Kansas 66046.

by K1ZJH

Circle #308 on Reader Service Card.

Communications Receivers Principles and Design

The art of designing communication receivers incorporating the various analog and new digital techniques is frequently kept a well guarded trade secret. The new book, Communications Receivers Principles & Design (McGraw-Hill Book Company, ISBN 0-07-053570-1) by Ulrich L. Rohde (DJ2LR/KA2WEU) and T. T. Nelson Bucher makes this information available to the interested community. The original manuscript was developed from courses given at the University of Gainesville, Florida and George Washington University in Washington by Dr. Rohde, where he was appointed adjunct professor of electrical and computer sciences. Both authors have a successful career in the field. Dr. Rohde, while at RCA, had directed the Military communication business area which had major government contracts in this field, and Dr. Bucher was responsible for many of the modern signal processing technologies and hardware designs and implementation at RCA. The reader, therefore, can expect a wealth of useful information to be found within the book as a result of the authors considerable background.

The book, divided into 10 chapters, considers the following subjects:

1. Basic Radio Considerations
2. Radio Receiver Characteristics
3. Receiver System Planning
4. Antennas and Antenna Coupling
5. Amplifiers and Gain Control
6. Mixers
7. Frequency Control and Local Oscillators
8. Demodulation and Demodulators
9. Other Receiver Circuits
10. Receiver Design Trends

The authors have provided a nice mix of theoretical and practical information. Many useful detailed circuits are shown and systems analyses and trade-off studies are included. The intense use of special modulation methods by the Services to provide reliable communication even under poor propagation has prompted the authors to provide a good theoretical introduction into this field as well as detailed practical performance examples.

"Communications Receivers Principles and Design" will, with its cogent mix of theory and practical information appeal to radio amateurs, students in the field of radio communications and engineering managers who need a comprehensive overview of all the techniques.

Available from Ham Radio Bookstore for $69.95 postpaid.

K2RR

SAY YOU SAW IT IN ham radio!



new accessories from ICOM

Instant satellite communications are now possible with ICOM's CT-16 Satellite Interface Unit when used with an ICOM CI-V System Transceiver. The CT-16 features an uplink switch to control the downlink and uplink transceivers, and a switch to select either normal or reverse tracking. The CT-16 may also be used in coordination with the UX-14 CI-IV/CI-5 converter. The suggested list price is $97.50.

The UX-14 Converter enables you to adapt a CI-IV system to a CI-V system. This allows the transceiver to be computer controlled, or for satellite operations using the CT-16 Satellite Interface Unit. The following radios are equipped with a CI-IV port and can be converted for CI-V use with the UX-14: IC-R71A, IC-271A, IC-271H, IC471A, IC-471H, IC-751, IC-751A and IC-1271A. The converter is priced at $72.50.

Radio operations can now be externally controlled by a RS-232C I/O port equipped personal computer by using ICOM's CT-17 Communication Interface-V (CI-V) Level Converter. Up to four ICOM CI-V radios can be used for controlling frequency, mode and memory information. Suggested List Price is $97.50.

To complement the growing activity on 220MHz, ICOM now has a 220MHz repeater available, the RP-2210. With frequency coverage from 216-236 MHz, selectable CTCSS/Carrier squelch operating system, and 25 watts RF output power, DTMF control and continuous duty cycle. The RP-2210 is a great way to get out of the mainstream activity. The Suggested List Price of the repeater is $1499.00.

Now ICOM offers the HM-46 and HM-46L Handheld Speaker Mic. The mini-sized speaker mic, HM-46 is big on audio for top panel connections on the IC-2AT, IC-02AT, IC-3AT, IC-03AT, IC-4AT and IC-04AT and the HM46L right angle connection speaker mic for the Micro series. Both the HM-46 and HM-46L have a swivel clip on the back to easily clip on your lapel or collar. The Suggested List Price of each mic is $29.99.

Circle #307 on Reader Service Card.

morse code tutor program

MFJ Enterprises, Inc. has released its new MFJ-1266 and MFJ-1267 Morse Code Tutor Program/Iambic Keyer/Keyboard. This new program for the Commodore C-64 and C-128 not only teaches Morse code, but also functions as an iambic keyer and Morse keyboard. With the optional MFJ-76 interface board ($19.95), you can plug in an external keyer paddle and key a transmitter or transceiver.

The disk version, MFJ-1266, retails for $19.95 and the cartridge version, MFJ 1267, retails for $29.95.

The program follows the format of the ARRL's *Tune in the World* and can be used with that course with MFJ's own code learning course.

The MFJ Morse Code Tutor such features as Select Random, which lets you choose the letters you wish to study; Complete Random, which sends all letters, numbers and punctuation randomly; Random Message, which sends a plain English message exactly as given on an FCC test or received on the air; Message Store, which lets you enter a message from the keyboard and store it for sending.

Each mode can use normal CW spacing or the special Farnsworth spacing that sends characters at a fast pace, but lengthens spaces between characters.

A copy of a test similar to a FCC Novice license test is included in the manual.

For additional information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #306 on Reader Service Card.

dual-band amplifier

A *dual-band amplifier?*

Yes.

The HL-725D is a dual-band power amplifier for the 144 and 440 MHz bands ,with low noise GaAs FET RX pre-amps. The HL-725D uses a large heat sink and the circuits of THL's stable, reliable HL-62V and HL-60U models. Because IN/OUT connectors are installed for both amplifiers, various combinations of dual TX and RX amplifiers can be used. Priced at $329.95, the HL-725D's are available from Encomm dealers.

For details, contact Encomm, Inc., 1506 Capital Avenue, Plano, Texas 75074.

Circle #304 on Reader Service Card.

700 series towers

Microflect's new 12-page catalog describes the light-duty 700 Series tower, designed for cellular, UHF, VHF, and small microwave antenna applications. The standard three-legged tower configuration is available in 10-foot increments up to 160 feet.

The 700 Series easily adapts to Microflect's 800 Series towers to provide greater heights when required.

The accessories section in the catalog includes pipe mounts, beacon light mounts, and grounding kits for the 700 Series. A price list is also included.

Complimentary copies will be sent on request. Contact Microflect Company, Inc., P.O. Box 12985, Salem, Oregon 97309-0985.

Circle #303 on Reader Service Card.

firm grip

Fix-O-Fix is a vacuum suction pad that holds virtually any object firmly in any position — horizontally, vertically, sloping, or upside down — on almost any flat surface. Attachment is easy; to disengage the vacuum, simply turn the pad to the left.

Fix-O-Fix is available for just $5.00 plus $1.00 shipping and handling directly from LWC Enterprises, 38 West Center, Logan, Utah 84321.

Circle #305 on Reader Service Card.

new rotor control option

Engineering Consulting has announced several new features for the Super Com Shack 64 remote base and repeater controller.

The advanced beam rotator control option (model HM-1) allows your system to control the Ham "M," Ham 4 or similar (i.e., CDR) rotators, complete with voice-announced bearings. The rotor option works in conjunction with the CS-8 relay card and the new HM-1 voltage-to-frequency converter, which plugs into the cassette port. The HM-1 samples a voltage from the rotor control box meter, which provides beam headings accurate to 1 degree. The control box switches (left, right, and brake on/off) are controlled via an interface cable that connects to the CS-8 relays No. 1, 2, and 3. An easy-to-install interconnect cable is used to parallel the control switches of the rotor control box, thereby allowing both manual and remote control of the rotor.

The HM-1 option ($49.95) operates in conjunction with the model CS-8 relay control board and CS64S Version 3.0 software. Program enhancements include provisions to allow using the remaining five open collector outputs on the CS-8 to activate external relays or controlling the CS-8 for programming the dip switch of a CTCSS (sub-tone) Encoder or Decoder. While in the directed page mode or from a mobile, it's possible to access up to 32 tones to individuals or groups. Whenever a station is being voice-paged, the selected tone is sent to enable the receiver audio to open the receiver squelch. Additional Version 3.0 software enhancements include the ability to quick dial (two digits) all 300 stored telephone numbers. Version 3.0 allows users to assign 32 CTCSSS (subtones) to groups or individuals, for automatic paging.

Version 3.0 is available to all Super Comshack 64 users who purchased the Model CS64S system since May 1, 1987 as part of Engineering Consulting's free upgrade policy.

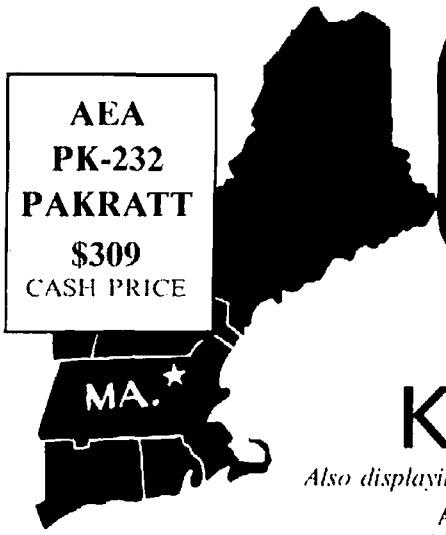
For information, contact Engineering Consulting, 583 Candlewood Street, Brea, California 92621.

new HAMRAD publication

HAMRAD Press now publishes a directory of DX station operating information — *The W1TQS DX Locator*, a monthly compilation of data relating to the operating times and frequencies of DX stations heard and worked during the current month contained in major DX newsletters, magazines, club bulletins, logs, and other sources.

Over 2500 reports of DX station activity are separately listed by time, frequency and call, providing a rapid reference of potential DX con-

AEA
PK-232
PAKRATT
$309
CASH PRICE



TEL-COM
Electronic Communications

NEW ENGLAND'S FACTORY-
AUTHORIZED SALES & SERVICE
FOR
KENWOOD ICOM

Also displaying the popular accessories needed to complete a HAM STATION . . .

ARRL PUBLICATIONS • AEA PRODUCTS • AMPHENOL
• ALPHA DELTA • ASTRON • AUSTIN ANTENNAS • AVANTI
• BELDEN • BENCHER • B & W • DAIWA • ALINCO
• HUSTLER • KLM • LARSEN • MIRAGE • ROHN
• TELEX/HY-GAIN • TOKYO HY-POWER LABS
• TRAC KEYERS • VIBROPLEX • WELZ • ETC.

195

KENWOOD
SEE THE NEW
POCKET PORTABLE
TH-25AT
FOR THE HAM
WHO MISSED OUT
AT CHRISTMAS

OPEN SIX DAYS A WEEK

Telephone 617/486-3400, 3040
675 Great Rd., (Rte. 119) Littleton, MA 01460
1¾ miles from Rte. 495 (Exit 31) toward Groton, Mass.

tacts available during any time of day, and on any band from 160 to 10 meters. Bar and pie chart graphics also characterize DX station operating habits by band and time period, to highlight optimum operating conditions.

The W1TQS DX Locator is intended to supplement — not replace — the many fine DX newsletters currently available. Subscriptions are available from HAMRAD Press, P.O. Box 2458, Springfield, Virginia 22152. A one-year subscription (via first class mail) is $35; foreign airmail rates are available upon request.

LCFIL filter design program

LCFIL, a stand-alone CAD program for IBM-compatible and Apple Macintosh computers, provides design solutions for lowpass, highpass, and bandpass filters having up to 21 poles. You can specify input impedance, inductor *Q*, and other parameters. Arbitrary component values may be entered into a general-purpose building block, which allows analysis of many other L-C filter topologies.

LCFIL computes filter magnitude, phase, and delay characteristics and provides normalized and actual component values. Both linear and logarithmic frequency steps are selectable. Optional modules provide for CGA, EGA, and Hercules-compatible graphical representation and drive 30 different popular pen plotters. An optional signal processing module works with LCFIL to provide transient analysis capability. Inputs are free-format with liberal error trapping.

The retail price of this program is $95. For details, contact BV Engineering, 2200 Business Way, Suite 207, Riverside, California 92501.

Circle #302 on Reader Service Card.

world time clock

The Azimuth Communications Corporation has announced a new World Time Clock, Model WT-80A, that features digital readouts with both local time and world time in 24-hour Zulu notation.



Designed around a special microprocessor, the quartz clock operates on a single oscillator. A slide switch selects display of the time in 24 cities around the world. (Universal/GMT time is shown when switch is set to London.)

Outside the shack, a press-on light and snooze alarm allow its use as a travel alarm clock. Two AAA penlight batteries are required.

As a special introductory offer, Azimuth is offering these world time clocks — a $29.95 value — at $19.95 plus $1.95 for postage and handling (California residents add state sales tax.) To order, or for more information, contact Azimuth Clock, 11845 West Olympic Boulevard, Suite 1100, Los Angeles, California 90064.

Circle #301 on Reader Service Card.

new tool kit

Jensen Tools has introduced a new tool kit for advanced students of electronics and skilled hobbyists. Also appropriate for small service shops and skilled home repair, the Deluxe Tech School Kit (No. 238002) includes screwdrivers, nutdrivers, a wire stripper/cutter, pliers, scissors, wrenches, a hemostat, a mirror, a holding tweezer, soldering equipment and more. A total of 28 quality tools are furnished in a 13-7/8 x 6-7/8 x 7 plastic tool box with lift-out tray, positive latch, and carrying handle. The kit is priced at $79.00.

For more information and free catalog, contact Jensen Tools, Inc., 7815 South 46th Street, Phoenix, Arizona 85044.

Circle #309 on Reader Service Card.

flea market

RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance.** No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

TEST EQUIPMENT WANTED. Don't wait — we'll pay cash for LATE MODEL *HP*, Tek, etc. *Call Glenn, N7EPK*, at Skagitronics Co. (800) 356-TRON.

HAMLOG COMPUTER PROGRAMS. 17 modules auto-logs, sorts / band WAS/DXCC. Full features. Apple $19.95, IBM or CP/M $24.95. KA1AWH, POB 2015, Peabody, MA 01960.

TEKTRONIX 7000 scope plug in's wanted: 7A, 7B, 7D, 7S, 7L series. Doug Rygalo, 13117 - 132 St, Edmonton, Alberta T5L 1R6. Phone (403) 453-1008.

I PAY CASH for new and used vacuum tubes, especially vintage and transmitting types. I also buy vintage audio equipment by Western Electric, Altec, McIntosh, Marantz, Westrex, et. Randy Nachtrieb, WA6GJA, 6392 Park Avenue, Garden Grove, CA 902645 (714) 897-9351.

WANTED ATLAS 350-XL. N5NM, Box 2169, Santa Fe, NM 87504 (505) 988-2305.

CLEANING HAMSHACK. Ham equipment, test equipment, manuals, radio parts, optics and antique radios/parts. Send business SASE for list. W6IEG, PO Box 1244, Oakhurst, CA 93644. (209) 683-8430.

WANTED: Swan 250, 6 meter (tube) SSB/CW transceiver and power supply. Richard McMahon, PO Box 316, FPO New York 09518.

R-390A Receiver: $115, electronically complete, repairable (*government-removed* meters, operation unaffected). R-390A parts; info SASE. Professional quality TS-352 Voltohm/Multimeter, AC-DC, with leads, manual: $12.50. Mint military spec pull-out 12AT7, 6BA6, 6AG5, 6AL5: $10/six. CPRC-26 Infantry Manpack Radio, 6 meter FM, receiver transmitter sections, cabinet, antenna, crystal, handset: $22.50, $42.50/pair. *H-251 Military Communications Headphones*: $7.50. Add $4.50/piece shipping ($9 maximum), except R-390A shipped collect. Baytronics, Box 591, Sandusky, OH 44870.

TEST EQUIPMENT for SALE. Many useful, quality items. General Radio 1001-A signal generator, lab grade, $100. GR-1650-A RCL Impedance bridge, $135. Tektronix 50 MHz plug-in units: Exc, 1A1 $100; 1A4, 4-trace $150. HP-130B audio scope, $50. HP-412A DC VTVM, Exc, $40. Microwave Equipment: HP-618B generator, 3.8-7.6 GHz, $150. FXR C772A, 3.9-8.2G, $75. Alfred 650 Sweep Gen. $200. HP-851B Spectrum Analyzer Display, $100. Boonton 260-A Q Meter, $250. Most have manuals. Large Variac, 22 amps, new, cased, boxed, retails $296, self $75. UTC commercial grade swinging chokes, 5-25Hy, 5000V, Exc, f/linear, $25/ea. Micamold capacitors, 2Mf, 4KV, $8/ea. Giant Tektronix service manuals, 465B, 475A $20/ea. List of Test Equipment manuals, SASE. Thermocouple wire, *Type J*, .18/ft. Joseph Cohen, 200 Woodside, Winthrop, MA 02152. (617) 846-6312.

SOLDERING STATION AND TOOLS, European and American. Free catalog. Robert Mink Import-Export, Box 6437R, Fair Haven, NJ 07704. (201) 758-8388.

WANTED TEN-TEC ARGONAUT. N5NM, Box 2169, Santa Fe, NM 87504. (505) 988-2305.

COMMODORE CUSTOM CHIPS FOR C64/128 Computer/Peripherals at low prices, 24 hour delivery: *#6510-$9.95, #6526-$9.95, #6567-$14.75, #6581-$12.85, PLA*-$12.50, 901 ROMS at $10.95 each and many others. "THE COMMODORE DIAGNOSTICIAN". A complete diagnostic reference chart for fixing Commodore computers, etc. An absolute must for those who want to fix their own computers and save money and down time. *$6.95 plus postage*...*HD Power Supply for C64 $27.95*... Send for complete chips/parts catalog... VISA/MC... Kasara Inc., 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-642-7634, 800-248-2983 (outside NY) or 914-356-3131.

SUPERFAST MORSE CODE SUPEREASY. Subliminal cassette. $10. Learn Morse Code in 1 hour. Amazing new supereasy technique. $10. Both $17. Moneyback guarantee. Free catalog. SASE. Bahr, 2549-H8 Temple, Palmbay, FL 32905.

UHF PARTS. GaAs fets, mimics, chip caps, trimmer caps, and other builder parts. MGF 1402 @$14.00. MFG 1302 @$10.00. .8-10pf. Trimtronics trimmer @$3.75. Porcelain chip caps @$1.75. Orders add $1.00 p+h. SASE for complete list. MICROWAVE COMPONENTS, 11216 Cape Cod, Taylor, MI 48180.

2.4 kHz AM Demodulator with 8 bit A-D and buffer. Copy WEFAX from GOES SATELLITES or APT from NOAA POLAR ORBITING SATELLITES. Created for use with Elmer Schwittek's Multifax 2.0 program. Order #206 KIT $49.95 or assembled and tested board Order #206-ASY $69.95. Add $2.50 shipping per order. For info on all our WEFAX products send SASE to: A & A Engineering, 2521 W. LaPalma, Unit K, Anaheim, CA 92801. (714) 952-2114.

NJ-NJ-NJ-NJ-NJ-NJ-NJ-NJ-NJ A Full Service Ham-SWL-CB Scanner store in NJ. Discount Grand Opening Prices. Top performing radio systems for every budget. New 10 meter and VHF/UHF rigs. ARRL, Amphenol, Astatic, Astron, Azden, B&W, Bilal Belden 9913, Butternut, Clear Channel, KLM, Larsen, MFJ, Mirage, Mil Spec Cables, much more. Open M-F 10 AM-9PM, Sat 10 AM-7 PM. Buy and sell used gear and have qualified repair facility. ABARIS SYSTEMS, 276 Oriental Pl, Lyndhurst, NJ 07071 (201) 939-0015.

WA9GFR COMMUNICATIONS SOFTWARE, $15.00 disk contains HF/VHF/UHF/L-Band propagation programs to predict range in miles based on transmitter power, receiver sensitivity, and antenna height & gain. A "must" for designing repeater installations. Also includes Smith Chart impedance matching programs. Commodore 64 or IBM. Lynn Geng, RR1, Monroeville, IN 46773.

SMART BATTERY CHARGER *for gell-cells or lead acid batteries*, by Warren Dion, W1BBH. See June '87QST Magazine for circuit details. Complete kit, nothing else to buy, only $49.95 plus $3.50 s/h. *Order #150-KIT.* A & A *Engineering*, 2521 W. LaPalma, Unit K, Anaheim, CA 92801.

IBM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, disk copy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. *David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.*

CHASSIS, CABINET KITS. SASE. K3IWK, 5120 Harmony Grove Road, Dover, PA 17315.

TELEVISION SETS made before 1946, early TV parts, literature wanted for substantial cash. Especially interested in "mirror in the lid" and spinning disc tv's. Finder's fee paid for leads. Arnold Chase, 9 Rushleigh Road, West Hartford, Conn. 06117. (203) 521-5280.

ENGINEERS request free catalog of Electronics Software. Circuit analysis, filter design, graphics, etc. BV Engineering, 2200 Business Way, Suite 207, Riverside, CA 92501 (714) 781-0252.

SUBCONTRACTORS WANTED by electronics manufacturer to *wire small pc boards*. Box 498, Greenville, NH 03048.

CODE PROGRAMS. Apple/C-64 128. 37 modes/graphics/lessons. LARESCO, POB 2018-HR, Calumet City, IL 60409. (312) 891-3279.

RADIO BROADCASTING EQUIPMENT WANTED for parts and rebuilding. Jon Hall, 98 Woodlake Drive, Charlottesville, VA 22901. (804) 978-1220 or (804) 973-8697.

RTTY JOURNAL—Now in our 35th year. Join the circle of RTTY friends from all over the world. Year's subscription to RTTY JOURNAL, $10.00, foreign $15.00. Send to: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

MARCO: Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

COMMODORE REPAIR. We are the largest/oldest Authorized Service Center in the country. (eg. C64 $39.95). Fast turnaround. Call Toll Free 1-800-642-7634, 800-248-2983, (outside NY) or 914-356-3131. Kasara Inc., 36 Murray Hill Drive, Spring Valley, NY 10977.

FOR SALE: 1 RACAL Model RA6778 0-30 MHz receiver. Excellent condition. $4200.00 US. Barrie Greenwood, VE3ADA, 248 - 30th Street, Etobicoke, Ont. Canada M8W 3E1. (416) 253-0708.

ANTENNAS ANTENNAS Austin VHF/UHF Tri-Banders, Yagis HF antenna experimenters kit, books. SASE brings lists. Ed Noll, W3FQJ, POB 75, Chalfont, PA 18914.

HAM LAB PROJECT. Want several pieces HP G-382A variable attenuator. Will consider any repairable condition. K6GOX, PO Box 10, O'Neals, CA 93645 (209) 868-3548 Collect.

30 YEARS PROVIDING QSL's. *Full color Old Glory, Cartoon.* Also Parchment, Golden Eagle and others. Free samples. SASE appreciated. Rusprint, Rt 1, Box 363-HR, Spring Hill, KS 66083.

YAESU FT-727-R COMPUTER INTERFACE. For info write Gerald Hogsett Consulting, 1581 Woodland, Palo Alto, CA 94303.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave - all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224 (213) 774-1255.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC. ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD *BE GREATLY APPRECIATED BY OUR BROTHER* SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

FLORIDA: January 30. The 8th annual Citrus County Hamfest sponsored by the Sky High Amateur Radio Club, County Fairgrounds Auditorium, 4 miles south of Inverness, Rt 41. Open to vendors 7 AM. General public 9 AM. Admission $3/advance, $4 door. Talk in on 146.355/955. For more information or tickets call Bob Gordon at (904) 628-5045 or write SHARC Hamfest, PO Box 572, Lecanto, FL 32661.

NEW YORK: January 31. The Yonkers ARC is sponsoring their Winter Electronics Fair, Lincoln High School, Kneeland Avenue, Yonkers. Admission $3.00. *Children under* 12 free. Sellers tables $10.00 or $1.00/ft. Advance registration for club provided tables. One person admitted free with every rented table. Sellers admitted 8 AM. Buyers 9 AM. Flea Market 9 AM to 3 PM. No tailgating. Free coffee all day. Talk in on 146.865 or 440.150. For information contact Otto Supliski, WB2SDQ (914) 969-1053 after 5 PM.

MICHIGAN: February 7. The 18th annual Livonia Amateur Radio Club's Swap 'n Shop, Dearborn Civic Center, Dearborn 8 AM to 4 PM. ARRL/VEC exams given by the Motor City Radio Club. Plenty of tables, refreshments and free parking. Talk in on LARC Repeater 144.75/5.35 and 146.52 simplex. For further information SASE to Neil Coffin, WA8GWL, *Livonia ARC, POB 2111*, Livonia, MI 48151.

MASSACHUSETTS: February 14. Electronics Flea Market sponsored by *the Algonquin* ARC, Marlboro Middle School Cafeteria, Union Street off Rt 85, *Marlboro*. 10 AM to 2 PM. Sellers 8 AM. Admission $2.00. Tables $8/advance; $10/door. WHEELCHAIR ACCESSIBLE. For more information Dan, KB1WW, (617) 481-1587 *or write AARC, Box 258, Marlboro*, MA 01752.

MICHIGAN: January 24. The Southfield High School ARC's 20th annual Swap & Shop, Southfield HS, 24657 Lahser, Southfield. Exhibitors admitted 6 AM. Public 8 AM to 3 PM. Admission $3.00. Reserved tables $20.00 for 2 8' tables paid in advance. Addit. reserved tables $10.00 each. All profits go to Electronic Scholarships and to support the Southfield HS Amateur Radio Club. For more information/reservations write Robert Younker, *Southfield* HS, 24675 Lahser, Southfield, MI 48034.

LOUISIANA: January 16. Southeastern Louisiana University ARC & SELARC's annual Hamfest, S.E. Louisiana University, 9 AM to 3 PM. Free admission. One free tables. Addit. tables $5.00 each. VE exams. Talk in on 146.4/147.0. For information Joe Magro, WO5R, 534 Iverstine Lane, Hammond, LA 70401.

INDIANA: SOUTH BEND. January 3. Hamfest Swap & Shop, first Sunday after New Year's Day at CENTURY CENTER down town on US 33 Oneway North between St. Joseph Bank Building and river. Four lane highways to door from all directions. Tables: $5/5 ft. round; $15 8x2.5 rectangular; $20/8 ft. Wall *locations. Talk in freq:* 52.52, 99-39, 69-09, 34.94, 145.29. K9IXU (219) 233-5307.

OPERATING EVENTS

"Things to do . . ."

January 30: The University of Idaho Amateur Radio Club, W7UQ, will hold its third annual "Alumni Reunion on the Air", 2100 UTC, Saturday, to 0300 UTC, Sunday. The goal is to make 100 contacts to celebrate the *U of I* centennial. *Listen for* "CQ Reunion" on phone and "CQ R" on CW. Color QSL available for SASE to Callbook address.

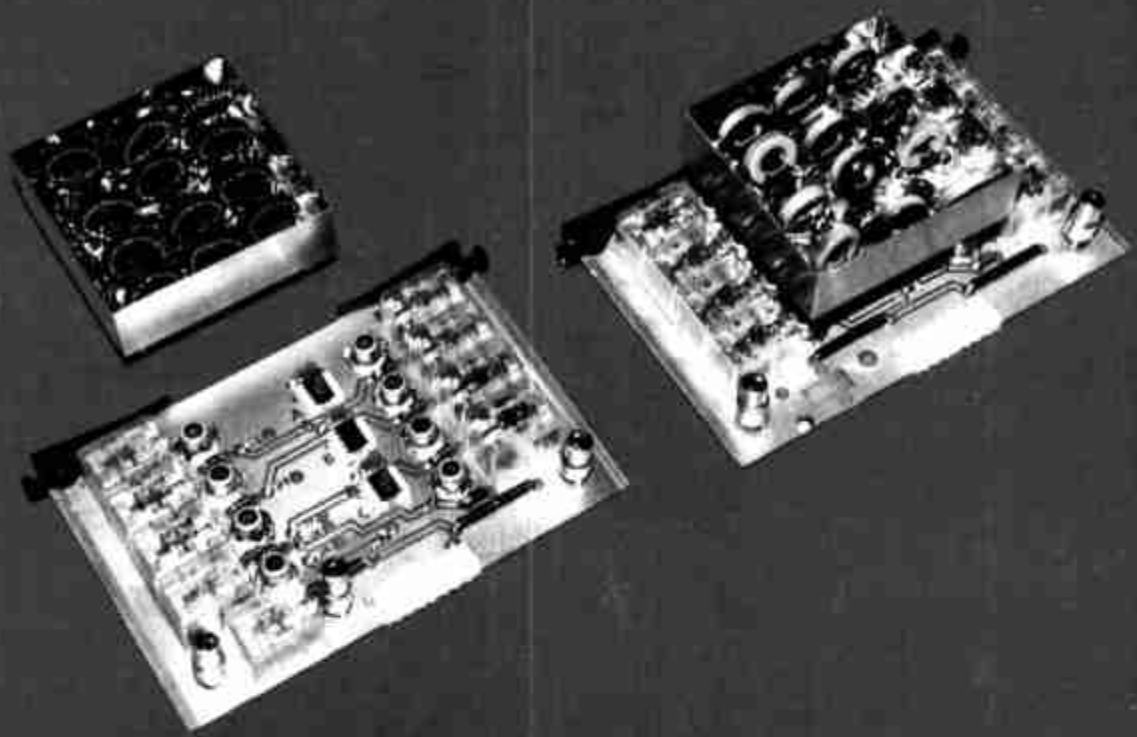
February 5-14. NORAC, the North Okanagan Radio Amateur Club, will operate a special event station daily during the Vernon Winter Carnival, Canada's largest winter carnival. Listen for VE7NOR. For a special commemorative certificate send QSL and 2 IRC's or $1.00 to NORAC, Box 1706, Vernon, BC V1T 8C3.

FEBRUARY 1988 / $2.50

amateur packet radio

ham radio magazine

ham radio • February 1988



automatically switched half-octave filters

...cus
...mmunications
...chnology

ham radio magazine

FEBRUARY 1988

volume 21, number 2

T. H. Tenney, Jr., W1NLB
publisher

Rich Rosen, K2RR
editor-in-chief
and associate publisher

Terry Northup
assistant editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
editorial production

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Rally Dennis, KA1JWF
director of advertising sales

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Farm Color
cover

ham radio magazine is published monthly by Communications Technology, Inc. Greenville, New Hampshire 03048-0498
Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail),
one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 97

Microfilm copies are available from University Microfilms, International Ann Arbor, Michigan 48106
Order publication number 3076

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1987 by Communications Technology, Inc.
Title registered at U.S. Patent Office

Second-class postage paid at *Greenville, New Hampshire* 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *ham radio*
Greenville, New Hampshire 03048-0498

contents

10 automatically switched half-octave filters: part 1
Cornell Drentea, WB3JZO and Lee R Watkins

33 amateur packet radio networking and protocols, part 1
Jonathan L. Mayo, KR3T

41 designing a station for the microwave bands: part 1
Glenn Elmore, N6GN

65 radial line stub design
George W. Allen, N1BEP

68 ham radio techniques: "the greatest little magazine in the world"
Bill Orr, W6SAI

77 practically speaking: noise, signals, and amplifiers
Joe Carr, K4IPV

82 VHF/UHF world: loose ends
Joe Reisert, W1JR

98 Elmer's notebook: standing wave ratio — what does it mean?
Tom McMullen, W1SL

106 advertisers index and reader service
9 comments
90 DX forecaster
101 flea market
96 ham mart
74 ham notebook
92 new products
4 publisher's log
6 reflections



Help Wanted — Apply Within

Over 5 years ago, Rally Dennis was invited to Ham Radio for a job interview. I was immediately comfortable upon meeting him and felt his addition to Ham Radio's staff would be a perfect meld of personalities — and I was correct in my assumption. We have worked well together over the last few years and enjoyed our association. Working as a team, our advertising sales have been good; Rally deserves credit for 200% of the success. Truthfully, he has forgotten more about ad sales than many of us will ever know and he is a true master at his craft.

He has decided, however, to slow down a bit as he approaches his 70th birthday. Effective December 31, he will semi-retire from Ham Radio and become an independent advertising sales consultant for the magazine. This will allow him the best of both worlds. No more shows or early morning flights from Boston's Logan Airport — no need to hurry to work every day. Time can be spent on his auctioneering, Game Preserve Museum, and antique business. But Rally will stay in touch with his friends in the Amateur Radio business working out of our office and his home about five days per month.

One project that becomes imperative is to find a new person to fill Rally's shoes. If you have a sales or marketing background and would be interested in discussing the position as advertising salesperson, please send us a resume and other information of interest about yourself. Working at Ham Radio has plenty to offer. The virtues of living and working in southern New Hampshire are almost too numerous to mention. Suffice to say — we're not fighting traffic jams as we drive home at night. Centrally located to the ocean, Boston, and the mountains, Southern New Hampshire has something for almost everyone.

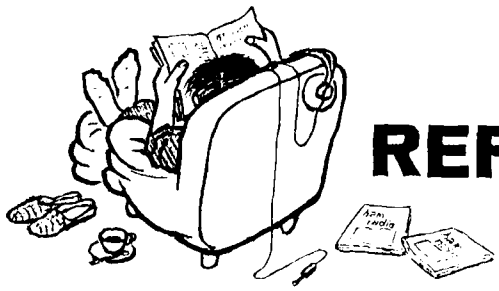


Photo by Phil Alix



Drop a note and your resume in the mail and we'll see about getting together for an interview to discuss this exciting opportunity. It's not too many jobs that require you to go to the Dayton Hamvention, all expenses paid, every year!

J. Craig Clark, Jr., N1ACH
Assistant Publisher



REFLECTIONS

RETURNING THE SPECTRUM TO CHAOS...Courtesy of the FCC

In the early years of wireless, radio communication was at best a chancy, chaotic business. Broadly-tuned spark-generated signals, received on primitive, unselective receivers, forced operators to wait for a break in the QRM to pass traffic or add their signal to the bedlam in hopes that the intended recipient would pick it up.

In the last 80 years, improved technology and international cooperation have brought order to the radio spectrum. With few exceptions, millions of transmitters in different services operate harmoniously under domestic and international regulations on designated frequencies or bands throughout the spectrum.

It now appears the FCC wants to turn back the clock — at least in the United States — and return much of the radio spectrum to its chaotic origins. In its recent Notice of Proposed Rule Making — General Docket 87-389 — the FCC proposes expanded use of unlicensed rf-emitting devices over most of the radio spectrum "without restriction as to bandwidth, duty cycle, modulation technique or application..." as long as their emissions do not exceed specified limits!

From 1.705-30 MHz, "Intentional Radiators" could generate signals measuring 30 μV/meter at a distance of 30 meters with NO radiation limitation for non-digital "Unintentional Radiators". The change in VHF/UHF limits to 100 μV/meter from 30-88 MHz, 150 SP^{6}mV/meter from 88-216 MHz, 200 μV/meter from 216-960 MHz, and 500 μV/meter above 960 MHz, all measured at 3 meters, is minimal.

Radio Amateurs would need an S9 signal to break through the rf bedlam on 10 to 160 meters. Because VHF/UHF band (signal) limits are already high, the effect won't be as pronounced. But similar problems would eventually occur since this proposal encourages expanding the uses of unlicensed rf generators. Any repeater without CTCSS access might be keyed up continuously and the hand-held range could become severely limited.

This eventual spectrum deterioration would affect more than the Amateur Radio community. All land mobile (police, fire) services, plus paging and radio-relayed telephones, would soon find themselves fighting their way through a cacaphony of rf noise. Even the U.S. military, AM, FM, and TV broadcasting, won't escape the havoc this proposal will bring. If your neighbors think your infrequent incursions into their TV viewing are a problem now, wait until they encounter proliferating unlicensed rf generation!

The proposal has some restrictions. A few narrow QRM-free slots would be reserved for radio astronomy, maritime distress, and navigational aids. Most VHF and UHF aircraft bands would be off limits to unlicensed operations, along with a couple of VHF federal land mobile bands. But for the rest of us, it'll be a problem.

This proposal applies to "Part 15" devices — intentional radiators (unlicensed low-power transmitters) like garage door openers, wireless microphones, and cordless telephones, and unintentional radiators (electronic devices) like computers, TV receivers, cable TV equipment, and VCRs which also emit some rf radiation. Over the years, the rules governing operation of these devices have been piecemeal, complex, confusing, and contradictory. This NPRM attempts to simplify and broaden Part 15 regulations without, the FCC believes, causing undue interference to existing services.

The Commission announced General Docket 87-389 in September with a comment due date of December 4 — too late for Amateur publications to review the proposal, its band-by-band summary and errata sheets, and relay the information to their readers with enough response time. Fortunately, organizations like ARRL and ANARC (Association of North American Radio Clubs), a SWL/scanner-user group, realized its importance and petitioned the Commission for an extension which was granted to March 7, 1988.

To tell the FCC of your opposition, file a written comment emphasizing the certainty of crippling interference to most established radio services. In his Comments filed before the original deadline, George Jacobs, W3ASK, noted that the internationally recommended signal-to-noise ratio for shortwave broadcast reception is 27 dB. The FCC's proposed interference levels would demand 672 microvolts from international broadcasters. But, Jacobs said, overseas broadcast signals generally run 150 to 500 μV. Radio amateurs are now communicating with a few microvolts.

Ask what *demonstrated* need there is for proliferation of such devices throughout the radio frequency spectrum. If a variety of frequencies for Part 15 devices is necessary, why not set aside specific frequencies or bands for them as was done with industrial, scientific and medical bands.

Point out that current techniques allow excellent frequency control and easy, economical transmission of large amounts of data in relatively narrow bandwidths. Why then, must so much spectrum be accessible to Part 15 use? Why shouldn't proper shielding be required to reduce Part 15 unintentional radiation to acceptable levels? Why should the licensed users of the spectrum be forced to carry the burden for poorly designed and manufactured consumer goods?

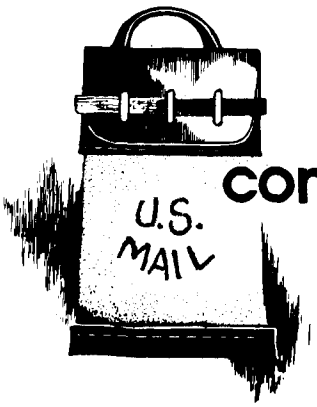
You'll probably think of more arguments to include with your Comments on General Docket 87-389, but whatever points you choose to emphasize, be sure the FCC knows how strongly you oppose it!

How do get your Comments to the FCC?

Type "Comments — General Docket 87-389" at the top of an 8-1/2 x 11 sheet of paper, state your argument, and end with your complete name, callsign, and address. If using more than one page, be sure to put the page number, your name, and the Docket number on each. Send it to Mr. William J. Tricarico, Secretary, Federal Communications Commission, 1919 M. Street, NW, Room 222, Washington, D.C. 20554 — preferably with the original and 11 copies (one for each commissioner). If you don't have access to a copier, your single submission will still make a difference.

Remember, *we must fight this proposal*. Your comments must reach the Commission before March 7, so why not start writing now?

Joe Schroeder, W9JUV



comments

cover

Dear HR:

The front page graphic, depicting Ham Radio in the December issue, was indeed a superb masterpiece.

That alone, is more than enough to keep a "honest-to-goodness" ham solidly attached to your fine magazine. The remaining contents, strictly a generous bonus.

Ray Ziminski, K2KC
East Meadow, New York 11554

wanted: hf amplifier

Dear HR:

In regards to the comment made by W7WRQ in the December 1987 issue of HR—he is correct. An SCR-270 radar unit was used and if I remember two antenna bays were used instead of the usual one. I worked on the composite tests on Sandy Hook, New Jersey in 1941 to get them ready for Pearl Harbor. I never knew that it was a problem to get "high powered" hf transmitters going in the '30s. They were on SSB also! While I did have a Collins transmitter with an intermittant cold solder joint that I had a heck of a time finding, Art Collins was an outstanding ham and Orr's article should be well received.

I am interested in a solid-state 500-1000W hf amplifier. The designs and/or built-up units that I can find are 10-12 years old. I know there are new 300-600W FETs. I can't seem to find any design material, kits, parts, or built-up units. If you have any pending articles, know of any source of parts, kits, boards, designs, whatever, I would like to know about the availability. I might even produce an article if I get an HF amplifier going to my satisfaction.

Wayne W. Cooper, AG4R
Miami Shores, Florida 33150

computerized Yagi beam antenna

Dear HR:

Having just received the August issue, I noted with a great deal of interest the writeup on the "computerized Yagi beam antenna" and especially the captions on the modified 205BA.

Having owned one for over a year, I have investigated a number of possible modifications, inclusive of a possible alteration to a wide-spaced four elements on a 45-foot boom, which modelled quite well.

The main attraction in Wayne Hillenbrand's design is in achieving the stated performance while maintaining the original boom length, as the 2-inch boom of the HY-GAIN would not take the extra stress very well, when extended to 45 feet.

As there are quite a few hams interested in improving the performance of their 205BA's, may I suggest that a more detailed presentation be included in one of your future issues.

Keep up the good work.

Julian S. Biermann, ZS6BJO
Germiston 1407, South Africa

great reference

Dear HR:

Just finished devouring the December issue and thought I'd send a quick note to share some thoughts.

I was mentioning last night to a friend that Ham Radio is the only (of many I receive!) magazine which I save in its entirety for reference. Seems there's always something interesting to read and learn. The December issue is a perfect example of what I meant!

I've always liked W1JR's columns. Bill Orr's column about Art Collins was touching. I never knew Art, but had a very close friend (W4MJJ, now Silent Key) who did. The stories Mel used to tell about Art and Curt Lemay during the early days of amateur SSB were always fascinating. Bill did well.

KL7AJ's article about TV didn't teach me anything new, but it was an incredibly well written review — more of what makes HR great.

I guess the bottom line is that HR is great! Please accept my thanks for HR's contribution to ham radio and to RF technology. Keep it up!

LCDR James A. Sanford, USN, PE, WB4GCS, Hampton
Virginia 23669

the good old days

Dear HR:

I wanted to let you know how much I enjoyed reading about Mr. Collins. I could not afford Collins for many years. I now own an S-line (32S-1/75S-1) and it is a treasure to me.

Thank Mr. Orr for writing about "the good old days," Mr. Collins and Collins Radio.

Robin Chestnut, WA5YGR
Perry, Oklahoma 73077

automatically switched half-octave filters: part 1

Want to exceed FCC purity-of-emissions specs? Try combination low-pass/band-pass filters.

The authors have developed a system of switched filter banks for use in equipment where contiguous, controlled bandwidth and sometimes constant delay designs are required over wide frequency ranges. Although the design presented here is intended for constant harmonic attenuation from 2 to 30 MHz, the concepts extend to more than just hf communications. — Ed.

In the good old days, radios had several bands. Mechanical band switching was accomplished by means of a multiwafer switch that extended all the way from the front panel to the back panel, with complex filter networks in between. While some of these systems are still in operation today, the introduction of digitally synthesized transceivers has brought about the need for a totally new approach to band switching. While it is a relatively simple matter to design channelized, band-switched rf equipment, the design of true broadband solid-state transceivers requiring stringent harmonic attenuation and linear phase response specifications over several hf octaves would require a multitude of band-switched filters. Using a manual band switch such as those found in old transceivers would lead to a cumbersome and impractical design.

On the other hand, one could look at a general-coverage hf synthesized radio as a device having one huge band, with an ultimate resolution of, say, 10 Hz. This would make it practical to digitally control simple, stand-alone, wide-range varactor-tuned filters which are small in size and require simple control circuits. While such circuits would be adequate in receiver environments with relatively low-level undesirable signals, the nonlinear nature of the varactor diodes can cause intermodulation distortion in the presence of higher level signals, *despite* the fact that back-to-back circuits are usually used to reduce this effect. If a transmitter is also involved, such as in the case of a transceiver, these circuits would become impractical; besides, high-power, contiguously switched filters are usually preferred. The proper selection of these filter networks requires digital intelligence in order to allow automatic coverage of the entire spectrum of interest. This, in turn, requires a unique system design.

Because there are four octaves* of bandwidth from 2 to 30 MHz, half-octave filters could be used in the system in order to keep out the second harmonic and the higher products of any of the 2,800,000 possible fundamentals (when using 10-Hz resolution) produced by the synthesizer. This concept is illustrated in **fig. 1**. Several half-octave filters will be required to meet this need. The important issue faced by a designer in such a case is not what microprocessor to use to crunch the numbers, but rather what is the best cost/complexity/performance compromise allowable by the total system design — both from a digital point of view and, more importantly, from an rf point of view. Understanding this process of design is the essence of this article.

* One octave is defined as the frequency range between a fundamental and its second harmonic.

By Cornell Drentea, WB3JZO, 7140 Colorado Avenue North, Minneapolis, Minnesota 55429, and **Lee R Watkins**, 2256 East Jaeger Street, Minneapolis, Minnesota 85213

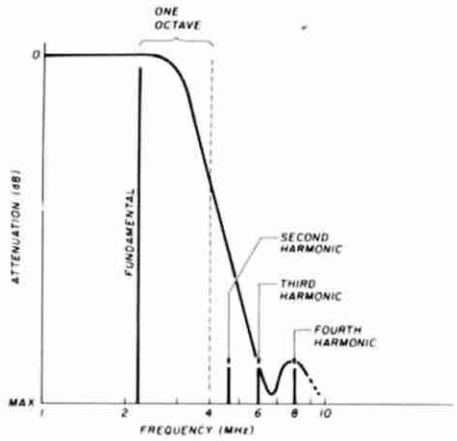


fig. 1. How a half-octave filter attenuates harmonics. Since harmonics are located at least one octave away from any fundamental, a worst case analysis for the entire range of 2 to 30 MHz indicates that several contiguous filters covering half-octaves will reject harmonics always by the same amount. An automatic switched bank of eight half half-octave filters are required to cover the 2 to 30 MHz range.

design criteria

The system described here uses eight switched filters. To eliminate any possibility of intermodulation distortion, no diodes are used in the rf switching. The filters are of a high-order bandpass design working in harmony with eight additional high-power, low-pass filters of similar design. It can be seen that because of the half-octave choice, given proper design, the filters can effectively attenuate all harmonic products at any point in the frequency coverage between the specified 2 and 30 MHz. This design calls for a composite attenuation between the filters and the linear amplifier's own harmonic response of greater than 50 dB for the specified range when used with the 120-watt linear amplifier in the WB3JZO transceiver's output. This exceeds the FCC's Part 97.73 requirement for purity of emissions for Amateur equipment.* In addition, a passband ripple requirement of 0.1 dB† was imposed on the design of all filters in order to keep receiver input impedance, and consequently noise figure and sensitivity, constant.

Switching in the appropriate set of half-octave filters for the frequency of interest can be performed automatically by the digital information available from the transceiver's frequency command input. The areas of

* The FCC requirement below 30 MHz calls for power of any spurious emission from an Amateur transmitter or transceiver to be at least 40 dB below the mean power of the fundamental, *but not to exceed 50 milliwatts*.

† With a $Q = 100$ for the inductors, a ripple of approximately 0.05 dB has been realized in practice.

. . . a word from the authors

This article, dedicated to the memory of Anatol I. Zverev, describes the design and development of a 2- to 30-MHz switched filter system as used in the front end of a modern, fully synthesized transceiver. Intended as a brief tutorial, as well as a construction article reaching beyond this single application, it enables one to appreciate the complexity of modern equipment and filter design, and shows in detail the design and development of a complex switched filter system whose harmonic attenuation exceeds the requirements for Amateur equipment. Although the emphasis is on construction, no layouts or physical details are given in order to keep the length of the article within reasonable limits.

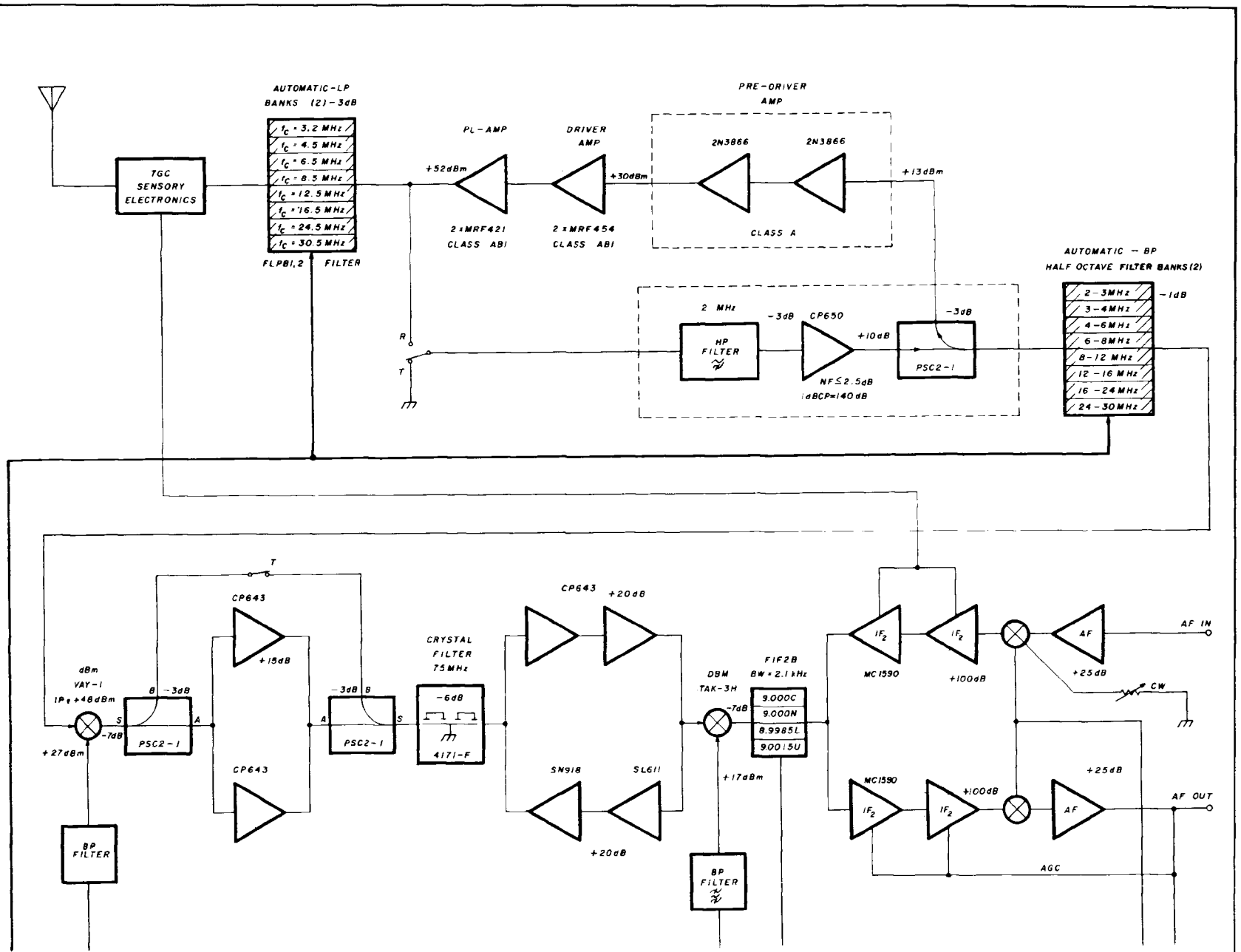
Part 1 discusses filter theory and design. Part 2 concentrates on implementation of the complex filter banks, digital control and execution, automatic high-power rf switching, and the practical aspects of the entire project as used in the WB3JZO home-built transceiver. It should be noted that this project is relatively complex and will thus not offer immediate gratification; it should be viewed, therefore, in the context of a larger project such as the design of a transceiver, receiver, or transmitter.

The project will apply to other automatic filtering applications of stand-alone, high-power, solid-state, hf linear amplifiers requiring stringent harmonic suppression and linear phase response over wide bands. These functions would be needed in order to reduce dynamic range requirements of co-located receivers or to provide phase-coherent data communications in installations requiring frequency diversity. In linear amplifier applications, a modified design (not described here) could contain sensory circuits to read the frequency of the rf present at the amplifier's input and quickly select the proper network at the output.

The article will also apply to receivers. The development of an off-board preselector which combines the techniques presented here with other techniques could be added to the front end of existent wide-band receivers to improve their in-band and out-of-band dynamic range performance.

We hope that this material is informative and useful for both beginners and advanced Radio Amateurs.

—Cornell Drentea, WB3JZO, and Lee R Watkins


AUTOMATIC-LP
BANKS (2)-3dB
fc = 3.2 MHz
fc = 4.5 MHz
fc = 6.5 MHz
fc = 8.5 MHz
fc = 12.5 MHz
fc = 16.5 MHz
fc = 24.5 MHz
fc = 30.5 MHz
FLPB1,2 FILTER
TGC SENSORY ELECTRONICS
PL-AMP
+52dBm
2 x MRF421 CLASS AB1
DRIVER AMP
+30dBm
2 x MRF454 CLASS AB1
PRE-DRIVER AMP
2N3866
2N3866
+13dBm
CLASS A
AUTOMATIC - BP
HALF OCTAVE FILTER BANKS (2)
2-3MHz
3-4MHz
4-6MHz
6-8MHz
8-12 MHz
12-16 MHz
16-24MHz
24-30MHz
-1dB
-3dB
PSC2-1
+10dB
CP650
NF≤2.5dB
1dBCP=+14dB
-3dB
HP FILTER
2 MHz
R
T
dBm
VAY-1
IP3 +48dBm
-7dB
+27dBm
B -3dB
S
A
PSC2-1
BP FILTER
T
CP643
+15dB
CP643
-3dB B
A
S
PSC2-1
CRYSTAL FILTER 75MHz
-6dB
4171-F
CP643 +20dB
+20dB
SN918
SL611
DBM TAK-3H
-7dB
+17dBm
BP FILTER
F1F2B
BW = 2.1 kHz
9.000C
9.000N
8.9985L
9.0015U
IF2
IF2
MC1590
+100dB
AF
+25dB
AF IN
CW
MC1590
IF2
IF2
+100dB
AF
+25dB
AF OUT
AGC

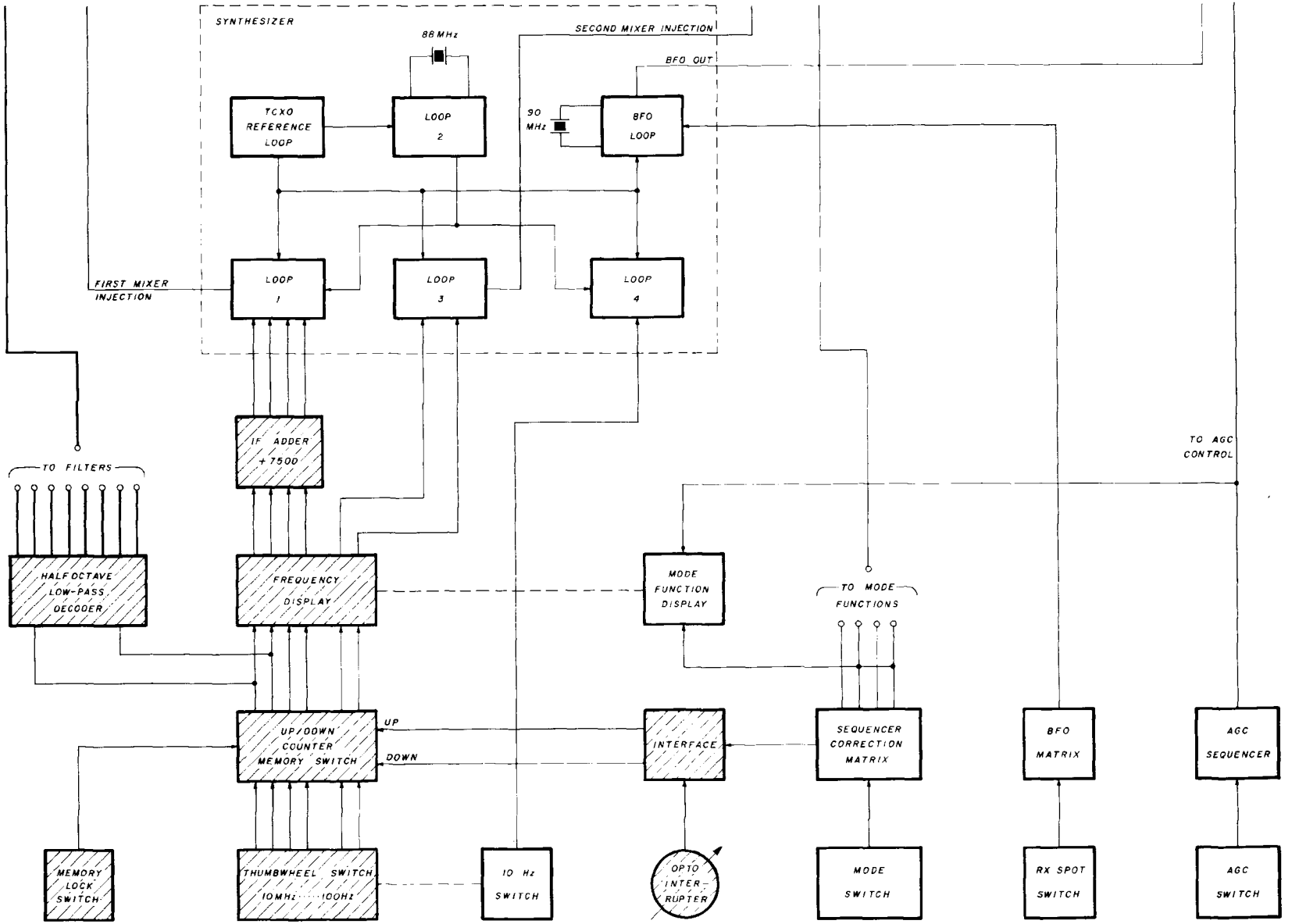


fig. 2. Areas of the transceiver discussed in this article. The block diagram shows the half-octave automatic filter system, which provides attenuation for harmonics generated by the wide-band transmitter. Low-pass filters are switched in along with bandpass filters. Total passband ripple does not exceed 0.1 dB.

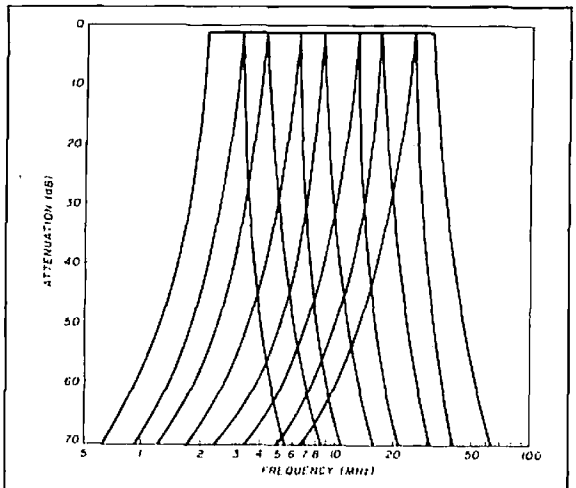


fig. 3. Composite frequency response for all lowpass and bandpass, half-octave filters. No matter where the fundamental frequency is generated by the transmitter, total harmonic content will always be at least 50 dB below it.

the transceiver affected by this article have been outlined in the block diagram shown in fig. 2, which illustrates that both the low-pass and the bandpass banks are always in the circuit regardless of whether the transceiver is in receive or transmit. Only one filter set and its corresponding pair are in the path at any given time.

A class A/AB amplifier has been specifically designed to keep the second harmonic down and therefore simplify the filter design requirement. The level of the third harmonic which is the worst-case product will determine the overall attenuation required by the filters and consequently their order and design type. However, since the third harmonic is further away from the corner frequencies of the half-octave bands, a less complex filter is required. This criterion is valid for all the frequencies and their corresponding harmonics in each of the eight filters, as affected by the linear amplifier's harmonic characteristics.

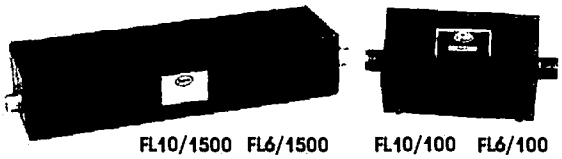
This principle also applies in receive, where the image, a third-order product, and higher order products are kept out of the receiver's input in any of the eight selected ranges through a combination of bandpass and low-pass filters. The image rejection specification for a receiver with a first i-f of 75 MHz, using the front-end filters designed here, has been calculated to be 70 dB.

So far we have determined the overall characteristic response of our filters as matching at least a 50-dB harmonic attenuation requirement when used with a specifically designed amplifier. This composite frequency response is shown in fig. 3. We will now examine the design of the filters more closely.

Because of the relatively large physical size of the

T.V.I. problems?

Low pass T.V.I. filters from Barker & Williamson



FL10/1500 FL6/1500 FL10/100 FL6/100

Model	Power (Watts)	Cut Off Frequency	Frequency of Maximum Attenuation	Minimum Attenuation	Frequency Range	Price
FL10/1500	1000	34 MHz	52 MHz	70 db	18 - 30 MHz	$32.00*
FL10/100	100	44 MHz	57 MHz	60 db	18 - 30 MHz	$23.50*
FL6/1500	1000	55 MHz	63 MHz	70 db	6 meter	$38.00*
FL6/100	100	55 MHz	63 MHz	50 db	6 meter	$27.00*

All above to match 50 ohm transmitters and antennas.

*Add $2 shipping and handling

ALL OUR PRODUCTS MADE IN USA

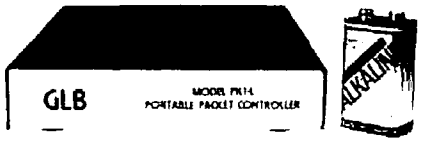
B&W **BARKER & WILLIAMSON**

Quality Communication Products Since 1932
At your Distributors write or call
10 Canal Street, Bristol PA 19007
(215) 788-5581

MasterCard VISA

GLB PACKET RADIO GOES PORTABLE

THE FIRST CONTROLLER DESIGNED FOR PORTABLE AND SOLAR-POWERED STATIONS



- LOW 25 mA Current Drain
- Miniature size - Lightweight
- Rugged metal, shielded case
- Lithium Battery backup for RAM
- Onboard Watchdog for reliability
- Standard DB25 Connectors
- "Connected" Status output line
- Remote Commands in Unattended Mode with Hardware Lockout
- Retains all other PK-1 features
- Extra I/O lines for special applications

NEW SOFTWARE FEATURE:
INTELLIGENT BUDLIST Provides selective callsign filtering for Digipeating, Monitoring and Connecting

Model PK1-L
Wired/Tested
List price $209.95
Amateur net $179.95

Power requirement: 9 to 15 Volts DC at 25 mA typical
Dimensions: 4.6 X 5.9 X 1.0 inches **Total Weight** 12 ozs

Please specify call sign, SSID number, and baud number when ordering.
Contact GLB for additional info and available options.
We offer a complete line of transmitters and receivers, strip preselector preamps, CW ID ers & synthesizers for amateur & commercial use.
Request our FREE catalog. MC & Visa welcome.

187

GLB ELECTRONICS, INC.
151 Commerce Pkwy., Buffalo, NY 14224 716-675-6740 9 to 4

table 1A. Bandpass. Design requirements for all half-octave filters used in the transceiver.

Filter No.	Passband (MHz)	Stopband (MHz)	Attenuation (dB)
1	2-3	<.625; >5.25	70
2	3-4	<.875; >7.75	70
3	4 6	<1.25; >10.5	70
4	6-8	<1.75; >15.5	70
5	8-12	<2.50; >21.0	70
6	12-16	<3.50; >31.0	70
7	16-24	<5.00; >42.0	70
8	24-30	<6.75; >61.0	70

table 1B. Lowpass. Design requirements for all half-octave filters used in the transceiver.

Filter No.	Cutoff (MHz)	Stopband (MHz)	Attentuation (dB)
1	>3	6	60
2	>4	9	60
3	>6	12	60
4	>8	16	60
5	>12	24	60
6	>16	36	60
7	>24	48	60
8	>30	72	60

parts required for the construction of the low-pass filters, it was decided that the lowest order filter that satisfied the above criteria would be considered in order to conserve space. First, the linear amplifier chain was designed and developed in order to realize a second harmonic attenuation of 30 dB. As mentioned before, the rejection requirements have been met by complementing these specifications with the linear amplifier's own harmonic attenuation.

During amplifier design, a nonlinear transfer function analysis was performed with the help of the Volterra series.* The data obtained was then compared with the harmonic content information available from Motorola's *RF Data Manual* and the actual spectrum analyzer data obtained from the designed amplifier. After several design iterations, the second harmonic emission was brought within the specification.† This placed a 20-dB attenuation requirement on all low-pass half-octave filters at the second harmonic in order to achieve the required 50 dB. The worst-case third harmonic emission was verified at 10 dB below the carrier. This placed a 60-dB attenuation requirement on the low-pass filters at the third harmonic frequencies and beyond in order to maintain a specified 70-dB total rejection. **Table** 1 lists all the resulting electrical requirements for the bandpass and low-pass filters.

A more stringent requirement intended for linear amplifiers with a lesser second harmonic rejection was

* Unlike the classic model to Fourier analysis, the Volterra series is a much more precise modeling tool used in the study of nonlinear effects in transistor amplifiers and receivers.

† The 39-dB gain amplifier uses a combination of class A/AB designs.

Join AMSAT...Today

'Amateur Radio Satellite OSCAR 10 provides:

- **A New Worldwide DX Ham Band** open 10 hours a day.
- **Rag Chew With Rare DX Stations** in an uncrowded, gentlemanly fashion.
- **Popular Modes In Use:** SSB, CW, RTTY, SSTV, Packet
- **Full Operating Privileges** open to Technician Class licensee or higher.

Other AMSAT Membership Benefits:

Newsletter Subscription: Dependable technical articles, satellite news, orbital elements, product reviews, DX news, and more.

Satellite Tracking Software Available for most popular PCs.

QSL Bureau, AMSAT Nets, Area Coordinator Support, Forum Talks

Construction of Future Satellites For Your Enjoyment!

AMSAT Membership is $24 a year, $26 outside North America. VISA and MC accepted.

AMSAT
P.O. Box 27
Washington, DC 20044

301 589-6062

185

worked out but was not implemented because of its complexity (it required a minimum of eight poles). However, the performance of the filters described here in standard solid-state, push-pull power amplifiers of class AB or B with matched characteristics and with a typical second harmonic rejection of 20 dB below the carrier or better, will also meet or exceed the 40-dB FCC requirement for Amateur service.

the ideal theoretical filter

The following is a discussion of the basic theory required for understanding of the filter design part of the article. Because filter articles can become very involved, we chose to emphasize only limited theoretical aspects of the subject. Only the bandpass design of one filter will be treated in detail. However, references to the low-pass equivalent design and detailed construction data are provided.

There are many ways to design filters. An ideal filter has no insertion loss in its passband (0 dB attenuation from $\omega = 0$ to $\omega = 1$), and infinite attenuation everywhere else. ($\omega > 1$!) as illustrated in **fig. 4A**. Mathematically, the value of the magnitude response function $|H(j\omega)|$ in such a filter would be infinite, which in turn would require an infinite number of poles. Finally, the filter would not be practical since an infinite number of poles would create an infinite insertion loss and an infinite delay for the waveform at its output. In addition, the ideal filter would require a linear phase response over the entire passband, as shown in **fig. 4B**. Other important elements affected in such a design would be the impulse and step response characteristics as shown in **figs. 5A** and **5B**. It can be seen that for the two responses, the output of the filter starts at $t = -\infty$ while the input is only applied at $t = 0$, a real-world impossibility.* This brief theoretical discussion is important because it makes us realize the imperfection of any filter design by comparison.

practical filters

Because actual filters can be no more than approximations of ideal filters, tradeoffs of performance characteristics are inevitable. Knowing what is important in each particular application determines the type of approximation. Designers have many filter types to choose from: Butterworth, Chebyshev, Legendre, Gaussian, Least-Square, Laguerre, Hermitian and Bessel; each is an approximation of the ideal filter, and each has its own positive characteristics. Chebyshev filters have an equal-ripple passband and steepest out-of-band attenuation (i.e., monotonically increasing attenuation). Since a 0.1-dB passband ripple specifi-

* The linear phase and constant group delay requirements imply that the response be of an anticipatory nature. The impulse response is obtained from the Fourier inversion integral. This integral produces a response which starts at $-\infty$ and ends at $+\infty$.

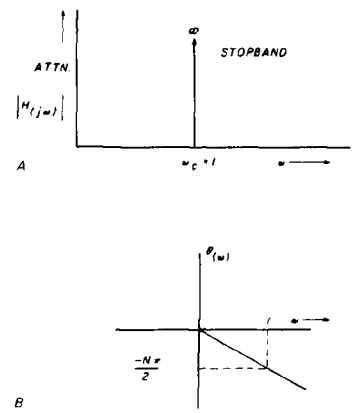


fig. 4. Ideal filter. (A) Amplitude frequency response. (B) Linear passband phase response.

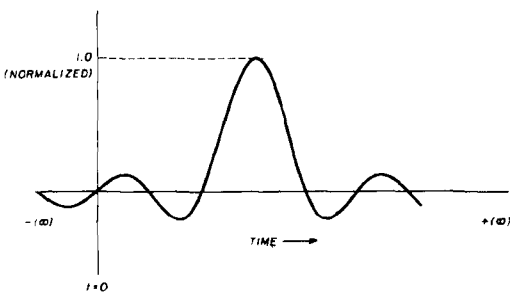


fig. 5A. Ideal filter. Impulse response.

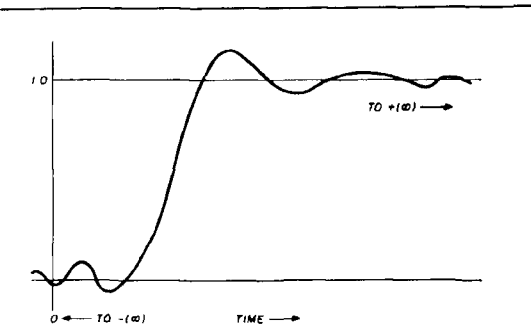


fig. 5B. Ideal filter. Step response.

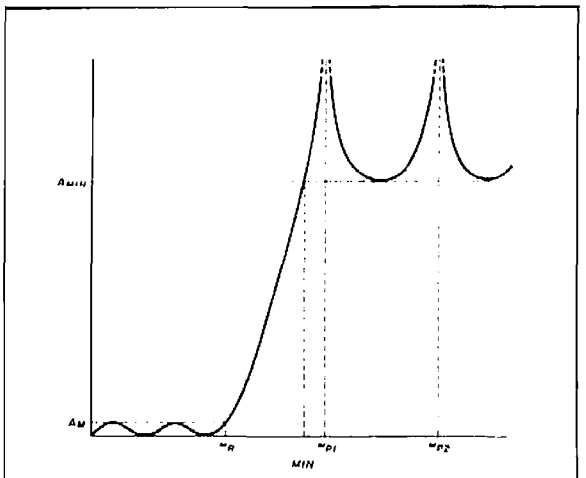


fig. 6A. Cauer elliptic filter. Low pass amplitude response.

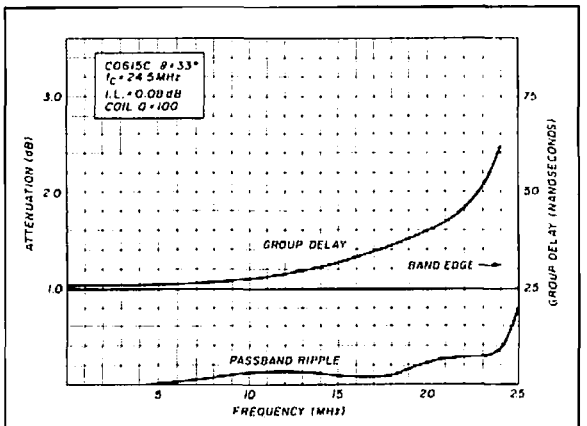


fig. 6B. Insertion loss (passband ripple) and group delay performance (Filter no. 7 from *table 1*). A "Q" of 100 was used in the calculations.

cation is needed for the entire 2- to 30-MHz range, a low-pass, half-octave, Chebyshev filter that has this characteristic is an eighth-order design and is too complex. If the ripple requirement were relaxed, a seventh-order design would be sufficient, but peaks in the ripple would make construction very sensitive to adjustment of component values and their variations with temperature. Duplicating the effort by a factor of 16 filters would be difficult.

compromise filter requirements

Any compromise filter would have to meet the following criteria:

• conform to the electrical design values shown in table 1;

K.V.G.
CRYSTAL PRODUCTS

9 MHz CRYSTAL FILTERS

MODEL	Application	Bandwidth	Poles	Price
XF-9A	SSB	2.4 kHz	5	$61.00
XF-9B	SSB	2.4 kHz	8	89.00
XF-9B-01	LSB	2.4 kHz	8	125.00
XF-9B-02	USB	2.4 kHz	8	125.00
XF-9B-10	SSB	2.4 kHz	10	165.00
XF-9C	AM	3.75 kHz	8	89.00
XF-9D	AM	5.0 kHz	8	89.00
XF-9E	FM	12.0 kHz	8	89.00
XF-9M	CW	500 Hz	4	62.00
XF-9NB	CW	500 Hz	8	145.00
XF-9P	CW	250 Hz	8	175.00
XF-910	IF noise	15 kHz	2	21.00

10.7 MHz CRYSTAL FILTERS
WRITE FOR FULL DETAILS OF CRYSTALS AND FILTERS
Export inquiries invited — Shipping $3.75

ANTENNAS 183

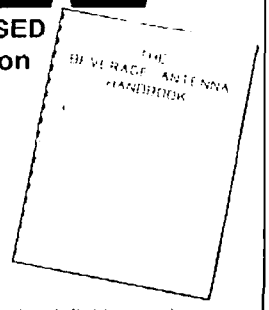
2M			
10XY-2M	$85.00	LOOP YAGIS	
70cm		1268-LY	$60.00
70/MBM28	60.00	1296-LY	$60.00
70/MBM48	90.00	1691-LY	$75.00
70/MBM88	120.00	order loop yagi connector extra	
DY20-900 MHz	80.00		

Send 66¢ (3 stamps) for full details of all our VHF & UHF equipments and KVG crystal products
Shipping FOB Concord, Mass
Prices subject to change without notice

MasterCard VISA

Si
(617) 263-2145
SPECTRUM INTERNATIONAL, INC.
Post Office Box 1084
Concord, MA 01742, U.S.A.

new
FULLY REVISED
Second Edition



BEVERAGE ANTENNA HANDBOOK
by Vic Misek, W1WCR

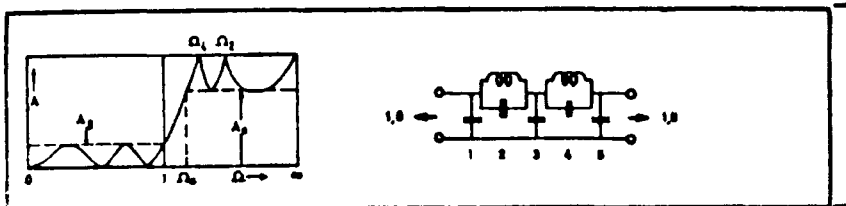
Recognized around the world as the definitive work on Beverage Antennas. W1WCR has spent countless hours developing new antenna ideas and optimizing the SWA (Steerable wave antenna.) Misek delves deep into the secrets of the single wire Beverage with helpful hints and tips on how to maximize performance based upon wire size, height above ground, overall length and impedance matching. Also includes information on center fed Beverages constructed out of several wire types. *CITY LOT OWNERS* Note: Misek has developed a Beverage for you too! Called the Micro-SWA, it is just 60 ft long. You get excellent directivity and null steering capabilities. Transformer design information for both termination and feedline matching is completely revised. • 1987 80 pages 2nd Edition

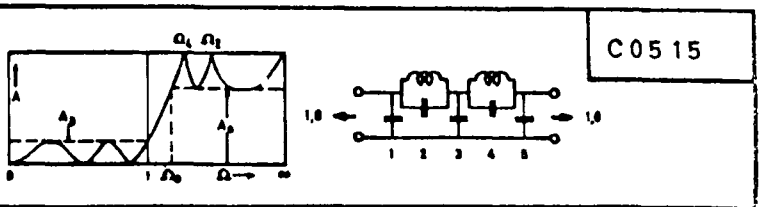
☐ **VM-BAH** **Softbound $14.95**

Please enclose $3.50 for shipping and handling

ham radio BOOKSTORE VISA
GREENVILLE, NH 03048 *603-878-1441*

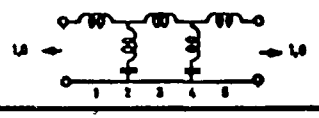
C0515





Θ	Ω_S	a_S[N]	A_S[db]	C_1	C_2	L_2	Ω_2	C_3	C_4	L_4	Ω_4	C_5
T	∞	∞	∞	1,144	0,000000	1,372	∞	1,972	0,000000	1,372	∞	1,144
06	9,566 772	14,94	129,7	1,142	0,002768	1,368	16,246 767	1,965	0,007259	1,362	10,056 467	1,137
07	8,205 509	14,16	123,0	1,141	0,003771	1,367	13,925 961	1,962	0,009893	1,359	8,624 709	1,135
08	7,185 297	13,50	117,2	1,140	0,004930	1,366	12,185 377	1,959	0,01294	1,355	7,551 553	1,132
09	6,392 453	12,90	112,1	1,139	0,006246	1,365	10,831 605	1,956	0,01641	1,351	6,717 466	1,129
10	5,758 770	12,37	107,5	1,138	0,007720	1,363	9,748 603	1,952	0,02030	1,346	6,050 729	1,125
11	5,240 843	11,90	103,3	1,136	0,009353	1,361	8,862 521	1,947	0,02461	1,340	5,505 703	1,121
12	4,809 734	11,46	99,5	1,135	0,01115	1,359	8,124 130	1,943	0,02936	1,335	5,051 963	1,117
13	4,445 411	11,05	96,0	1,133	0,01310	1,357	7,499 346	1,938	0,03455	1,328	4,668 444	1,112
14	4,133 565	10,68	92,8	1,131	0,01522	1,355	6,963 824	1,932	0,04018	1,321	4,340 101	1,107
15	3,863 703	10,33	89,7	1,130	0,01750	1,352	6,499 710	1,926	0,04627	1,314	4,055 901	1,102
16	3,627 955	10,00	86,9	1,128	0,01995	1,350	6,093 615	1,920	0,05282	1,306	3,807 568	1,096
17	3,420 304	9,70	84,2	1,125	0,02257	1,347	5,735 299	1,913	0,05984	1,297	3,588 776	1,090
18	3,236 068	9,41	81,7	1,123	0,02536	1,344	5,416 798	1,906	0,06735	1,289	3,394 603	1,083
19	3,071 553	9,13	79,3	1,121	0,02832	1,341	5,131 623	1,899	0,07535	1,279	3,221 164	1,076
20	2,923 804	8,87	77,0	1,118	0,03146	1,337	4,875 347	1,891	0,08385	1,269	3,065 351	1,069
21	2,790 428	8,62	74,9	1,115	0,03478	1,334	4,643 295	1,882	0,09287	1,259	2,924 648	1,061
22	2,669 467	8,38	72,8	1,113	0,03827	1,330	4,432 337	1,874	0,1024	1,248	2,796 996	1,053
23	2,559 305	8,15	70,8	1,110	0,04195	1,326	4,239 719	1,865	0,1125	1,237	2,680 696	1,044
24	2,458 593	7,94	68,9	1,107	0,04582	1,322	4,063 150	1,855	0,1232	1,225	2,574 331	1,036
25	2,366 202	7,72	67,1	1,103	0,04988	1,318	3,900 700	1,846	0,1345	1,212	2,476 711	1,026
26	2,281 172	7,52	65,3	1,100	0,05413	1,313	3,750 741	1,835	0,1463	1,199	2,386 829	1,017
27	2,202 689	7,33	63,6	1,096	0,05858	1,309	3,611 883	1,825	0,1588	1,186	2,303 827	1,007
28	2,130 054	7,14	62,0	1,093	0,06323	1,304	3,482 936	1,814	0,1720	1,172	2,226 971	0,9963
29	2,062 665	6,95	60,4	1,089	0,06809	1,299	3,362 873	1,803	0,1858	1,158	2,155 627	0,9856
30	2,000 000	6,78	58,8	1,085	0,07316	1,293	3,250 805	1,791	0,2004	1,143	2,089 247	0,9744
31	1,941 604	6,60	57,4	1,081	0,07845	1,288	3,145 956	1,779	0,2157	1,128	2,027 351	0,9629
32	1,887 080	6,44	55,9	1,076	0,08396	1,282	3,047 049	1,767	0,2317	1,112	1,969 523	0,9509
33	1,836 078	6,27	54,5	1,072	0,08970	1,276	2,955 288	1,754	0,2486	1,096	1,915 395	0,9386
34	1,788 292	6,11	53,1	1,067	0,09567	1,270	2,868 346	1,741	0,2664	1,080	1,864 643	0,9259
35	1,743 447	5,96	51,8	1,062	0,1019	1,264	2,786 358	1,728	0,2850	1,063	1,816 980	0,9128
36	1,701 302	5,81	50,4	1,057	0,1084	1,258	2,708 909	1,715	0,3047	1,045	1,772 152	0,8993
37	1,661 640	5,66	49,2	1,052	0,1151	1,251	2,635 631	1,701	0,3253	1,027	1,729 930	0,8853
38	1,624 269	5,52	47,9	1,047	0,1221	1,244	2,566 192	1,686	0,3470	1,009	1,690 112	0,8710
39	1,589 016	5,37	46,7	1,042	0,1293	1,237	2,500 299	1,672	0,3699	0,9901	1,652 516	0,8563
40	1,555 724	5,24	45,5	1,036	0,1369	1,229	2,437 673	1,657	0,3939	0,9709	1,616 977	0,8412

Θ	Ω_S	a_S[N]	A_S[db]	L_1	L_2	C_2	Ω_2	L_3	L_4	C_4	Ω_4	L_5



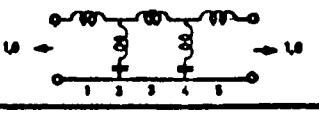
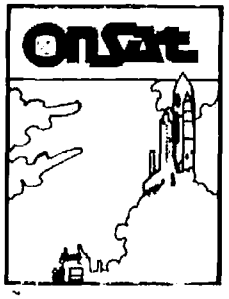


fig. 7. Fifth order Cauer (Elliptic) filter, adapted from: Von R. Seal, Der Entwurf von Filtern mit hilfe des Kataloges normierter Tiefpasse, AEG-Telefunken, 715 Backnang, West Germany, 1968, pages 86-87.

OnSat

"America's Weekly Guide to Satellite TV"



The best in satellite programming! Featuring: ★ Over 120 Channels listed ★ Weekly, Updated Listings ★ Magazine Format ★ Complete Alphabetical Movie Listings ★ Sports Specials ★ Prime Time Grids ★ Specials ★Programming Updates!

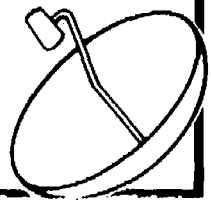
- **Only $45.00 per year (52 weekly issues)**
- **2 Years $79.00 (104 weekly issues)**
- **$1.00 for sample copy**

*NC Residents must add 5% Sales Tax

Subscribe Today!

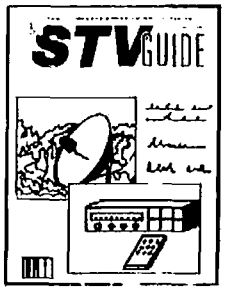
call toll free 1-800-234-0021
Visa* and MasterCard* accepted

OnSat PO Box 2347 Shelby, NC 28151-2347



STV GUIDE

The new **STV Guide** contains valuable information on zoning regulations, scrambling, plus technical tips for installing or updating a satellite system—and now a precise monthly guide to satellite TV with the latest program listings for over **90 channels**!



All this in each complete issue of **STV Guide**!

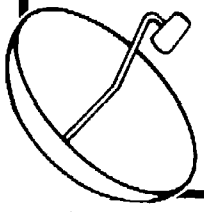
- **Only $48.00 per year (12 monthly issues)**
- **$2.00 for a sample copy**

*NC Residents must add 5% sales tax

Subscribe Today!

Call toll free 1-800-234-0021
Visa* and MasterCard* accepted

STV Guide PO Box 2384 Shelby, NC 28151-2384



180

- meet packaging requirements, using the minimum number of poles;
- be easy to design and economical to construct;
- be easy to tune with relatively simple laboratory equipment.

A Cauer (elliptical) filter has an in-band characteristic similar to that of a Chebyshev filter; it also has a more abrupt transition band characteristic than the monotonically increasing attenuation of the Chebyshev approach. A fifth-order Cauer is easier to tune than the more complex eighth-order Chebyshev that would have been required to meet the ripple spec.

The low-pass amplitude response of a typical Cauer filter is shown in **fig. 6A**. Insertion loss has been calculated and verified at 0.01 dB for the low-pass and approximately 1 dB for the bandpass design. The group delay remains relatively constant over the range as shown in **fig. 6B**.

Where: A_M is the magnitude of the passband ripple (expressed in nepers or dB):

$$dB \qquad 10 \log (1 \quad \rho) \qquad (1)$$

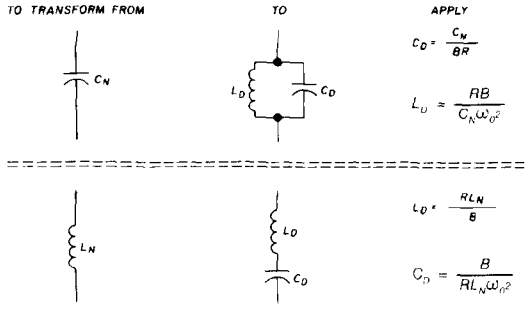
Note: while ρ is usually expressed as a percentage, the decimal value should be used in **eqn. 1**. W_R is the frequency of the ripple bandwidth normalized for ω = 1 radian. A_{MIN} is the minimum stopband attenuation in dB. ω_{MIN} is earliest frequency which has less or equal amplitude than A_{MIN} (ω_{MIN} is normalized to ω_R). ω_{P1}, ω_{P2}, are the frequencies of attenuation peaks, normalized to ω_R.

bandpass design

The 16- to 24-MHz design (filter No. 7) is analyzed according to data supplied in **table 1**. This filter is one of four (1, 3, 5, and 7) that have more stringent slope requirements on the low-frequency side of their 70-dB attenuation (a half-bandwidth ratio between the center frequency and the lower 70-dB attenuation point of 3.75:1), as can be seen from **table 1**. From the normalized tables of elliptic filters in **fig. 7**, we find that a fifth-order filter will meet the bandpass requirements, including the 0.1-dB passband ripple. The required attenuation will be determined by the conservative choice of θ = 21 degrees* which will provide more than 74.9 dB for all frequencies located 2.79 half-bandwidths away from the center frequency, more than enough to satisfy the above requirements. In addition, the design margin of 4.9 dB over the 70-dB design requirement is intended to compensate for possible theoretical vs. practical problems which may evolve during the implementation of the network. The filter has now been identified. The schematic diagram and its normalized electrical values can be extracted from **fig. 7**. This filter can also be defined as C0515 θ = 21

* θ = value of modular angle

table 2A. Equations used for the transformations from the lowpass to bandpass Elliptic functions.



To transform from the normalized lowpass element values, apply the following equations: (See program B)

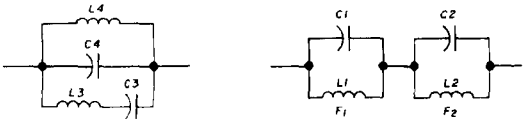
Where: B = Radian bandwidth of the design

ω_0 = Radian center frequency (geometric mean)

R = Value of input (source) resistor if elliptic or to the value of the output (load) resistor if other than an elliptic design

Table 2A

To transform from a parallel resonant-series resonant combination into two parallel resonant circuits in series with each other perform the following operations: (See program A)



$A = L_3 \cdot L_4 C_3 \cdot C_4$

$B = C_4 \cdot L_4 + C_3 \cdot L_3 + L_4 \cdot C_3$

$E = L_3 \cdot L_4 \cdot C_3$

$P = (B + SQR(B \cdot B - 4A)) \cdot 5$

$C_1 = (A \cdot A - A \cdot P \cdot P)/(A \cdot L_4 \cdot P - E \cdot P \cdot P)$

$C_2 = (A - P \cdot P)/(E - P \cdot L_4)$

$L_1 = (A \cdot L_4 - P \cdot E)/(A - P \cdot P)$

$L_2 = (P \cdot E - L_4 \cdot P \cdot P)/(A - P \cdot P)$

The two resonant frequencies F_1 and F_2 are

$$F_1 = \frac{1}{2\pi\sqrt{L_1 C_1}}$$

$$F_2 = \frac{1}{2\pi\sqrt{L_2 C_2}}$$

DRSI

DIGITAL RADIO SYSTEMS, INC.

The next era in Packet Radio is just over the Horizon

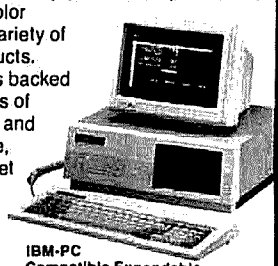


Free Famous hi-tech catalog

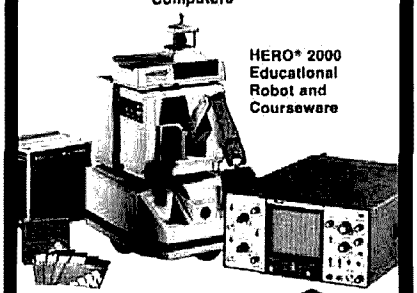


A very special guide to what the exciting world of computer and electronics kit-building can do for you.

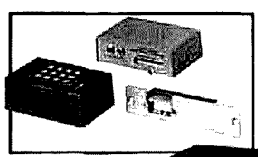
The informative Heathkit Catalog shows you more than 450 exciting electronic products that will challenge, instruct, and entertain you. You'll find countless kits that you can build and enjoy, from computers and robots to color tv's and a variety of home products. And each is backed by our years of experience and our promise, "We won't let you fail."



IBM-PC Compatible Expandable Computers



HERO® 2000 Educational Robot and Courseware



Precision Test Instruments

Electronic Keyless Doorlock



PackKit Multi-Mode TNC



Send NOW for your FREE Heathkit Catalog.

Send to: Heath Company, Dept. 122-622
Benton Harbor, Michigan 49022

Name _____

Address _____

City _____ State _____ Zip _____

A subsidiary of Zenith Electronics Corporation CL-784R3

Heathkit®
Heath Company

table 2B. IBM-Compatible programs used for simplifying the transformation calculations.

A

```
10 DIM Q$(3)
20 P1=3.14159
30 LPRINT "THIS PROGRAM TRANSFORMS A PARALLEL RESONANT - SERIES RESONANT"
40 LPRINT "COMBINATION"
50 LPRINT "INTO  TWO PARALLEL RESONATE CIRCUITS IN SERIES WITH EACH OTHER"
60 CLS
70 PRINT "ENTER THE VALUE (IN uHENRIES) OF THE SERIES INDUCTOR"
80 INPUT L3
90 PRINT "ENTER THE VALUE (IN uHENRIES) OF THE PARALLEL INDUCTOR"
100 INPUT L4
110 PRINT "ENTER THE VALUE (IN pFARADS) OF THE SERIES CAPACITOR"
120 INPUT C3
130 PRINT "ENTER THE VALUE (IN pFARADS) OF THE PARALLEL CAPACITOR"
140 INPUT C4
150 A=L3*L4*C3*C4
160 B=C4*L4*C3*L3*L4*C3
170 E=L3*L4*C4
180 P=(B+SQR(B*B-4*A))*.5
190 C1=(A*A-A*P*P)/(A*L4*P-E*P*P)
200 C2=(A-P*P)/(E-P*L4)
210 L1=(A*L4-P*E)/(A-P*P)
220 L2=(P*E-L4*P*P)/(A-P*P)
230 F1=1/(2*P1*SQR(L1*C1))*1000
240 F2=1/(2*P1*SQR(L2*C2))*1000
250 CLS
260 LPRINT "THE INPUT VALUES ARE:"
270 LPRINT "INDUCTANCE (uHENRIES)          CAPACITANCE (pFARADS) SERIES CIRCUIT"
280 LPRINT
290 LPRINT USING "*#.######^^^^                    ";L3;C3
300 LPRINT
310 LPRINT "INDUCTANCE (uHENRIES)        CAPACITANCE (pFARADS) PARALLEL CIRCUIT"
320 LPRINT
330 LPRINT USING "*#.######^^^^                    ";L4;C4
340 LPRINT
350 LPRINT "THE VALUES FOR THE TWO RESONANT CIRCUITS ARE:"
360 LPRINT
370 LPRINT "INDUCTANCE uH        CAPACITANCE pF        FREQUENCY MHz"
380 LPRINT
390 LPRINT USING "*#.######^^^^         ";L1;C1;F1
400 LPRINT USING "*#.######^^^^         ";L2;C2;F2
410 LPRINT
420 LPRINT
430 PRINT "DO YOU WISH TO ENTER ANOTHER SET OF DATA? Y/N"
440 INPUT Q$
450 CLS
460 IF Q$="Y" THEN 60
470 IF Q$="N" THEN 500
480 CLS
490 GOTO 430
500 CLS
510 END
```

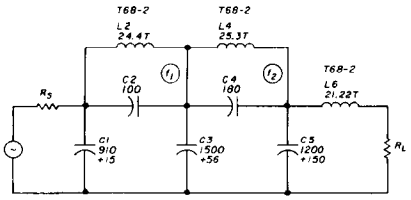
B

```
10 CLS
20 LPRINT "THIS PROGRAM COMPUTES THE NORMALIZED LOWPASS TO WIDEBAND"
30 LPRINT "BANDPASS TRANSFORMATION"
40 DIM A$(3)
50 P=3.14159
60 PRINT "ENTER THE VALUE OF THE CENTER FREQUENCY IN Hz"
70 INPUT F
80 PRINT "ENTER THE VAULE OF THE SOURCE RESISTOR"
90 INPUT R
100 PRINT "ENTER THE VALUE OF THE RIPPLE BANDWIDTH IN Hz"
110 INPUT B
120 LPRINT "THE CENTER FREQUENCY IS ";F;" Hz"
130 LPRINT "THE RIPPLE BANDWIDTH IS ";B;" Hz"
140 LPRINT "THE SOURCE RESISTOR IS ";R;" OHMS"
150 CLS
160 PRINT "ENTER THE VALUE OF THE NORMALIZED LOWPASS CAPACITOR (IN FARADS)"
170 INPUT C
180 C1=C/(2*P*B*R)
190 L1=R*2*P*B/(C*4*P*P*F*F)
200 LPRINT
210 LPRINT
220 LPRINT "NORMALIZED          L1                C1"
230 LPRINT "LOWPASS C         HENRIES           FARADS"
240 LPRINT
250 LPRINT USING "*#.#####^^^^      ";C,L1,C1
260 LPRINT
270 PRINT "ENTER THE VALUE OF THE NORMALIZED LOWPASS INDUCTOR (IN HENRIES)"
280 INPUT L
290 C1=2*P*B/(L*R*4*P*P*F*F)
300 L1=R*L/(2*P*B)
310 LPRINT
320 LPRINT "NORMALIZED          L1                C1"
330 LPRINT "LOWPASS L         HENRIES           FARADS"
340 LPRINT
350 LPRINT USING "*#.#####^^^^      ";L,L1,C1
360 LPRINT
370 CLS
380 PRINT "DO YOU WISH TO ENTER ADDITIONAL VALUES? Y/N"
390 INPUT A$
400 IF A$="Y" THEN 150
410 IF A$="N" THEN 440
420 CLS
430 GOTO 380
440 CLS
450 END
```

table 3. Calculated and practical (given in parentheses) values for the eight, half-octave lowpass filters used in the transceiver.

#1

I_C = 3.2 MHz BAND = 2 - 3 MHz
Reject 6 MHz by 60 dB
f_C: Reject = 1.875:1
Use A C0615C θ = 35° Filter
Minimum Attenuation At 6 MHz = 67.8 dB
Normalized values are:



R_S = 1	R_L = 1
C_1 = 0.9316	C_2 = 0.1082
L_2 = 1.368	C_2 = 1.564
C_4 = 0.1880	L_4 = 1.466
C_5 = 1.371	L_6 = 1.033
f_1 = 2.5989	f_2 = 1.9051

the denormalized values are:

R_S = 50	R_L = 50
C_1 = 926.7* pF (910 + 15)**	C_2 = 107.6 pF (100)
L_2 = 3.40 μH	C_3 = 1556 pF (1500 + 56)
C_4 = 187 pF (180)	L_4 = 3.65 μH
C_5 = 13.64 pF (1200 + 150)	L_6 = 2.568 μH
f_1 = 8.316 MHz	f_2 = 6.0963 MHz

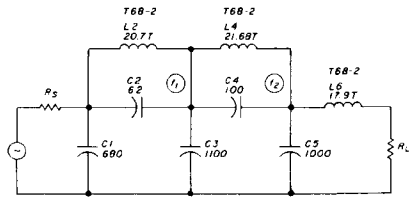
tune L_2, C_2 for an attenuation peak at f_1
tune L_4, C_4 for an attenuation peak at f_2

*Design value
**Actual value used

#2

I_C = 4.5 MHz Band = 3 — 4 MHz
Reject 9 MHz
I_C: Reject ratio = 2:1

Use a C0615C θ = 32° filter
Minimum attenuation at 9 MHz = 72.8 dB
Normalized values are:



R_S = 1	R_L = 1
C_1 = 0.9492	C_2 = 0.08912
L_2 = 1.393	C_3 = 1.601
C_4 = 0.1540	L_4 = 1.518
C_5 = 1.395	L_6 = 1.034
f_1 = 2.8385	f_2 = 2.06813

The denormalized values are:

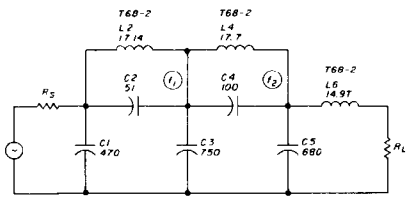
R_S = 50	R_L = 50
C_1 = 671.4 pF (680)	C_2 = 63 pF (62)
L_2 = 2.46 μH	C_3 = 1132.4 pF (1100)
C_4 = 108.9 pF (100)	L_4 = 2.68 μH
C_5 = 986.7 pF (1000)	L_6 = 1.83 μH
f_1 = 12.773 MHz	f_2 = 9.3066 MHz

tune L_2, C_2 for an attenuation peak at f_1
tune L_4, C_4 for an attenuation peak at f_2

#3

F_C = 6.5 MHz Band = 4 - 6 MHz
Reject 12 MHz
I_C: Reject = 1.846:1

Use a C0615C θ = 35° filter
Minimum attenuation at 12 MHz = 67.8 dB
Normalized values are:



R_S = 1	R_L = 1
C_1 = 0.9316	C_2 = 0.1082
L_2 = 1.368	C_3 = 1.564
C_4 = 0.1880	L_4 = 1.466
C_5 = 1.371	L_6 = 1.033
f_1 = 2.59897	f_2 = 1.9051

The denormalized values are:

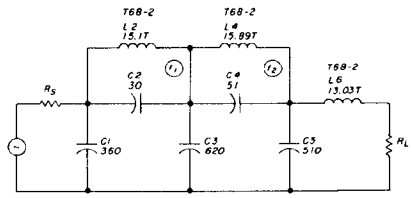
R_S = 50	R_L = 50
C_1 = 456.2 pF (470)	C_2 = 53 pF (51)
L_2 = 1.675 μH	C_3 = 766 pF (750)
C_4 = 92 pF (100)	L_4 = 1.79 μH
C_5 = 671.4 pF (680)	L_6 = 1.265 μ
f_1 = 16.893 MHz	f_2 = 12.383 MHz

tune L_2, C_2 for an attenuation peak at f_1
tune L_4, C_4 for an attenuation peak at f_2

#4

f_C = 8.5 MHz Band = 6 - 8 MHz
Reject 18 MHz
f_C: Reject = 2.11:1

Use a C0615C θ = 31° filter
Minimum attenuation at 18 MHz = 74.5 dB
Normalized values are:



R_S = 1	R_L = 1
C_1 = 0.9547	C_2 = 0.08325
L_2 = 1.400	C_2 = 1.612
C_4 = 0.1436	L_4 = 1.535
C_5 = 1.402	L_6 = 1.034
f_1 = 2.9287	F_2 = 2.1298

The denormalized values are:

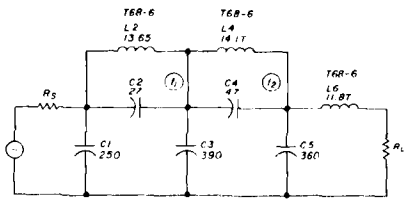
R_S = 50	R_L = 50
C_1 = 357.5 pF (360)	C_2 = 31.2 pF (30)
L_2 = 1.31 μH	C_3 = 603.7 pF (620)
C_4 = 53.8 pF (50)	L_4 = 1.44 μH
C_5 = 525 pF (510)	L_6 = 0.968 μH
f_1 = 24.894 MHz	f_2 = 18.1033 MHz

tune L_2, C_2 for an attenuation peak at f_1
tune L_4, C_4 for an attenuation peak at f_2

#5

f_C = 12.5 MHz Band = 8 - 12 MHz
Reject 24 MHz
f_C: Reject = 1.92:1

Use a C0615C ϕ = 34° filter
Minimum attenuation at 24 MHz = 69.4 dB
Normalized values are:



R_S = 1	R_L = 1
C_1 = 0.9377	C_2 = 0.101
L_2 = 1.376	C_3 = 1.577
C_4 = 0.1761	L_4 = 1.484
C_5 = 1.379	L_6 = 1.034
f_1 = 2.6741	f_2 = 1.9561

The denormalized values are:

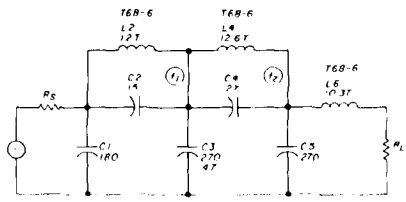
R_S = 50	R_L = 50
C_1 = 238.8 pF (250)	C_2 = 25.9 pF (27)
L_2 = 0.876 μH	C_3 = 401.6 pF (390)
C_4 = 44.8 pF (47)	L_4 = 0.945 μH
C_5 = 351.1 pF (360)	L_6 = 0.658 μH
f_1 = 33.426 MHz	F_2 = 24.451 MHz

tune L_2, C_2 for an attenuation peak at f_1
tune L_4, C_4 for an attenuation peak at f_2

#6

f_C = 16.5 MHz Band = 12 - 16 MHz
Reject 36 MHz
f_C: Reject = 2.18:1

Use a C0615C ϕ = 30° filter
Minimum attenuation at 36 MHz = 76.3 dB
Normalized values are:



R_S = 1	R_L = 1
C_1 = 0.96	C_2 = 0.0776
L_2 = 1.408	C_3 = 1.623
C_4 = 0.1337	L_4 = 1.551
C_5 = 1.410	L_6 = 1.034
f_1 = 3.02499	f_2 = 2.19586

The denormalized values are:

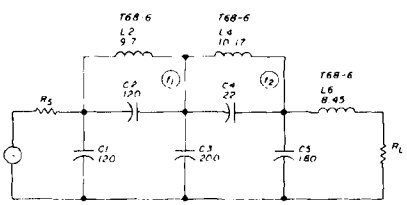
R_S = 50	R_L = 50
C_1 = 185.19 pF (180)	C_2 = 14.9 pF (15)
L_2 = 0.679 μH	C_3 = 313.1 pF (270 + 47)
C_4 = 25.8 pF (27)	L_4 = 0.748 μH
C_5 = 272 pF (270)	L_6 = 0.4987 μH
f_1 = 49.9123 MHz	f_2 = 36.2317 MHz

tune L_2, C_2 for an attenuation peak at f_1
tune L_4, C_4 for an attenuation peak at f_2

#7

f_C = 24.5 MHz Band = 16 - 24 MHz
Reject 48 MHz
f_C: Reject = 1.96:1

Use a C0615C ϕ = 33° filter
Minimum attenuation at 48 MHz = 71.1 dB
Normalized values are:



R_S = 1	R_L = 1
C_1 = 0.9436	C_2 = 0.09523
L_2 = 1.385	C_3 = 1.589
C_4 = 0.1648	L_4 = 1.501
C_5 = 1.387	L_6 = 1.034
f_1 = 2.75377	f_2 = 2.0103

The denormalized values are:

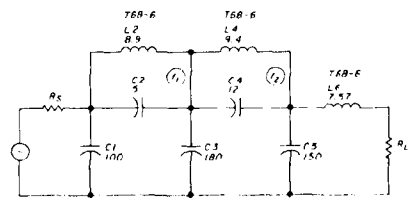
R_S = 50	R_L = 50
C_1 = 122.6 pF (120)	C_2 = 12.37 pF (12)
L_2 = 0.449 μH	C_3 = 206.4 pF (200)
C_4 = 21.4 pF (22)	L_4 = 0.487 μH
C_5 = 180.2 pF (180)	L_6 = 0.336 μH
f_1 = 67.467 MHz	f_2 = 49.252 MHz

tune L_2, C_2 for an attenuation peak at f_1
tune L_4, C_4 for an attenuation peak at f_2

#8

f_C = 30.5 MHz Band = 24 - 30 MHz
Reject 72 MHz
f_C: Reject = 2.36:1

Use a C0615C ϕ = 27° filter
Minimum attenuation at 72 MHz = 82 dB
Normalized values are:



R_S = 1	R_L = 1
C_1 = 0.9747	C_2 = 0.06212
L_2 = 1.429	C_3 = 1.654
C_4 = 0.1066	L_4 = 1.595
C_5 = 1.430	L_6 = 1.035
f_1 = 3.3568	f_2 = 2.4244

The denormalized values are:

R_S = 50	R_L = 50
C_1 = 101.7 pF (100)	C_2 = 6.5 pF (5)
L_2 = 0.373 μH	C_3 = 172.6 pF (180)
C_4 = 11.1 pF (12)	L_4 = 0.416 μH
C_5 = 149.2 pF (150)	L_6 = 0.270 μH
f_1 = 102.38 MHz	f_2 = 73.944 MHz

tune L_2, C_2 for an attenuation peak at f_1
tune L_4, C_4 for an attenuation peak at f_2

degrees, which means that it is a Cauer (C, elliptic) design of a fifth order (05), with ρ = 15 percent (see **fig. 6**), and θ = 21°, as described above. Its normalized design parameters are shown respectively in **fig. 8A** for the normalized low-pass element values and in **fig. 8B** for the denormalized bandpass element values. The transformation is performed with the help of several equations, which are listed in **table 2A**. The design for the remaining seven bandpass filters is performed in a similar manner.

Information about applying denormalizing equations is provided in the references, which will follow at the end of Part 2 of this article. To make the job easier, the transformation equations from the low-pass to the bandpass elliptic filter have been applied to computer programs for the IBM and compatibles, and are included in **table 2B**.

The final transformation for the C0515 θ = 21-degree filter is shown in **fig. 9**. Note that f_1, f_2, f_3, and f_4 are frequencies where the attenuation characteristic peaks. Knowledge of where they occur is very important for tuning the filters. This is accomplished by adjusting the individual inductances or capacitors for maximum attenuation at the respective frequencies.

Reasonable care should be exercised in choosing components as close as possible to the theoretical values. For example, actual capacitor values were chosen near the theoretical values and inductance tuning was accomplished by spreading or compressing the windings on the toroidal cores. This method worked well for all the networks.

low-pass design

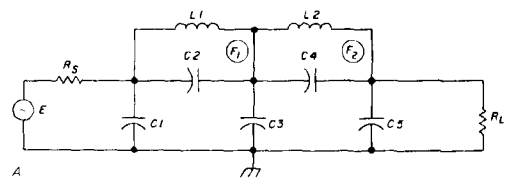
We have seen how a bandpass, half-octave Cauer (elliptic) filter, C0515, can be designed to meet stringent requirements and yet be easy to build. The design of the equivalent low-pass filters from **table 1** is performed in much the same way. Since a sixth-order filter is required for the low-pass bank to achieve the design requirements, the identification for this filter will be C0615c. (The "c" at the end indicates an equal source and load impedance.) The elliptical tables mentioned earlier (**table 2**) and **eqn. 2** and **3** below are used to denormalize the low-pass filter.

$$C_D = \frac{C_N}{R_S\,\omega_C} \qquad (2)$$

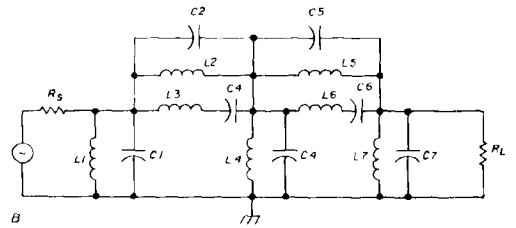
where C_D and L_D are the denormalized values. Where C_N and L_N are the normalized values,

$$L_D = \frac{L_N\,R_S}{\omega_C} \qquad (3)$$

R_S is the value of the source resistor, and ω_C is the cutoff frequency in radians.

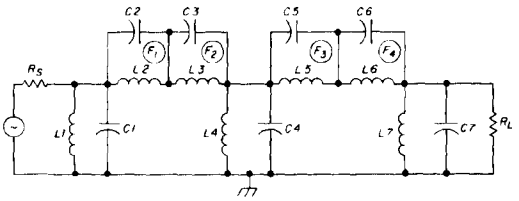


R_S = 1.000 ohms — R_L = 1.000 ohms
C_1 = 1.115 F. — C_2 = 0.03478 F.
C_3 = 1.882 F. — C_4 = 0.09287 F.
C_5 = 1.061 F.
L_1 = 1.334 H. — L_2 = 1.259 H.
F_1 = 4.643 Radians — F_2 = 2.925 Radians



R_S = 50.000 ohms — R_L = 50.000 ohms
C_1 = 412.69pF — C_2 = 53.79pF
C_3 = 12.87pF — C_4 = 696.58pF
C_5 = 56.99pF — C_6 = 34.37pF
C_7 = 392.71pF
L_1 = 0.161μH — L_2 = 1.23μH
L_3 = 5.16μH — L_4 = 0.0953μH
L_5 = 1.16μH — L_6 = 1.93μH
L_7 = 0.169μH

fig. 8. Schematic diagram and values for (A) normalized lowpass element, and (B) denormalized bandpass element of the bandpass filter.



R_S = 50.000 ohms — R_L = 50.000 ohms
C_1 = 412.69pF — C_2 = 15.01pF
C_3 = 90.27pF — C_4 = 696.58pF
C_5 = 44.60pF — C_6 = 149.88pF
C_7 = 392.71pF
L_1 = .160μH — L_2 = 0.736μH
L_3 = 4.42μH — L_4 = 0.0953μH
L_5 = 0.443μH — L_6 = 1.49μH
L_7 = 0.169μH
F_1 = 47.89MHz — F_2 = 7.966MHz
F_3 = 35.8MHz — F_4 = 10.65MHz

fig. 9. Final transformation for C0515 θ = 21° filter. Knowing where the peaks in attenuation are will greatly help in tuning the filter.

The final practical model for C0615c θ = 31 degrees is shown in **fig. 10**. The inductors were wound by hand on Micrometals™ toroidal cores, as we will see later.

INTERNATIONAL MONTHLY MAGAZINE BY AND FOR ACTIVE RADIOAMATEURS

Radiosporting

THIS IS IT! - FOR BIG GUNS & LITTLE PISTOLS

A magazine dedicated to quality and sportsmanship in amateur radio operating. Fresh, timely, practical and down to earth reading for little pistols and big guns. Written by the world's best in their fields: ON4UN, SMØAGD, LZ2CJ, VE3BMV, KH6BZF, DJ9ZB, ZS6BRZ, W1WY, N2AU, K7GCO, K4ZN, W4GF, VE3JTQ, WB4ZNH, WB9TBU, KQ2M, NS6X, W3FG, KA3B, K1PLR, N7CKD, VE3XN, ABØX, JE1CKA and others.

Includes DX News, QSL Info, 160m, 80m, 10m, 6m columns, DXpeditioning, Propagation, Awards, Contest rules and results, Traffic - Emergency, FCC News, New Products, Antennas, Technical news and articles, equipment reviews and modifications, computer programs, Radio Funnies, Club Life, RTTY, VHF/UHF, Mail Box, Classified Ads and much more in a magazine format with the speed of a bulletin.

RADIOSPORTING sponsors DX Century Award, Contest Hall of Fame and World Radio Championship contest.

"Your publication is superb! Keep it up!" **Joe Reisert, W1JR**

"Your W2PV articles are priceless. Your magazine is super!" **Rush Drake, W7RM**

"Let me congratulate you on a very impressive magazine. Just what I've been looking for as a DXer and Contester!" **Dick Moen, N7RO**

"RADIOSPORTING, once received, cannot be tossed aside until it is read from cover to cover. Then reviewed again and again." **Chas Browning, W4PKA**

Subscription rates: 1 year USA $18, Canada CDN$26, Overseas US$23; 2 years $33, $48, $42 respectively. Single issue $2. USA First Class Mail add $8/year, DX Air Mail add $15/year.

TRY US! SUBSCRIBE OR SEND $1 FOR YOUR SAMPLE COPY.
RADIOSPORTING Magazine
PO Box 282, Pine Brook, NJ 07058, USA ✓ 178

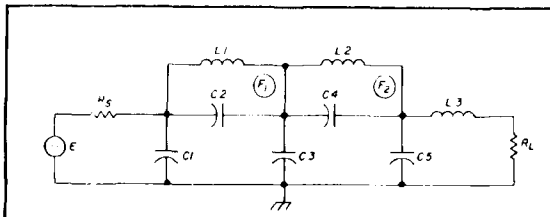


fig. 10. Realization of the practical lowpass, half-octave, Cauer (Elliptic) filter model. This model has been identified as CO615c. See text.

Table 3 shows the calculated and practical values for all eight half-octave, low-pass filters used in the transceiver. The numbers in parentheses are practical values as used in the implementation. Silver-dipped mica capacitors with a tolerance of ±5 percent were used throughout the networks. Breakdown voltages have been chosen at 250 volts.

Part 2 of this article will deal with the final implementation of the filters in the transceiver. In addition, automation and switching for the entire system will be discussed in sufficient detail to allow readers to design their own circuits.

ham radio

LIVE A DREAM... Winter In Florida
ORLANDO HAMCATION AND COMPUTER SHOW

Build your next vacation around the southland's most popular Hamfest, at the hub of the greatest entertainment and activity center in the east.

WHILE HAMCATIONING TAKE IN THE SIGHTS AT:

★ Disney World ★ Sea World
★ Kennedy Space Center ★ Epcot
★ Daytona Beach ★ Church Street Station ★ Busch Gardens
★ Cypress Gardens ★ Silver Spgs

ALL MAJOR EXHIBITORS EXPECTED

ARRL FLORIDA STATE CONVENTION
MARCH 11-13, 1988
at ORLANDO'S EXPO-CENTRE

UPGRADE! Volunteer Examinations by CAVEC • SUNDAY (March 13)
Send completed Form 610, photocopy of present license and $4.00 fee to:
R.V. Mackey, CVE, P.O. Box 1598, Maitland, Florida 32751
(WALK-INS ACCEPTED)

PLANNING AHEAD! Here's your Ham-Cation dates for the next four years:
MAR. 10-12, 1989 ★ MAR. 9-11, 1990
MAR. 8-10, 1991 ★ MAR. 14-16, 1992

★ **REGISTRATION** ★
$6 Advance • **$8** At Door
Banquet $12.50
Air-Conditiond Swap Table Area
Tables $25.00 ea.
Swap Table Area Open Friday at Noon
Get your Suntan as you Tailgate.
Four Hundred Positions
Tailgating: $20.00

Y'all C'mon Down and Enjoy Our Southern Hospitality

For Tickets, Swap Table and Tailgate reservations send Check or Money Order and SASE to:
ORLANDO HAMCATION & COMPUTER SHOW
Dept. QST, P.O. Box 547811 • Orlando, Florida 32854-7811
Reservations accepted until 2/15/88. Tickets held at Information Booth after that date.

amateur packet radio
networking and protocols, part 1

Introduction to a viable communications mode

Much has been written about Amateur packet radio over the past few years. Although the features and advantages of packet radio are well known by most active Amateurs, remarkably few operators understand how packet radio really works.

This three-part series describes the workings of packet radio. A basic reader understanding of the subject and some knowledge of the components and operating procedures are assumed.

I will cover two related areas that are integral to packet radio, networking and protocols. These concepts are viable when used with hardware systems (such as terminals, Terminal Node Controllers, and radios). All three components (hardware, networks, and protocols) work together, and a failure in one can result in total breakdown. The series introduces the subject of networks and protocols, explores the various options in each, and describes the common systems in use today.

network basics

A single packet station is useless for communications; two or more stations are needed. In terms of digital communications, a network can be defined as a collection of devices linked together so that one station can talk with *any other* station in the network. It is difficult to decide on and implement a system allowing for maximum flexibility and throughput while minimizing complexity and cost.

In the simplest case, a packet network consists of a few stations within direct communications range of each other on a single frequency (see **fig. 1**). A more complex network involves digipeating (simplex packet repeaters) to extend a station's communication range and gateways for accessing stations with different capabilities as shown in **fig. 2**.

This situation is not ideal because of congestion, range limitations, and other problems. Before more advances can be made in packet networking, additional work is needed in the area of protocols. Present day packet has stretched the current protocols to their limit, and much is being done to develop new ones.

multiplexing

Since packet operation occurs on agreed upon single frequencies, a method is needed that allows stations to access the frequencies in an orderly manner. Without this, operators using the frequency would collide with other users.

The method used is *multiplexing.* Multiplexing lets a group of users share a communication medium. In its ideal form, each user should be unaware that he is sharing the channel. The two forms of multiplexing that concern packet radio operators are Time Division Multiplexing (TDM) and Frequency Division Multiplexing (FDM).

FDM

FDM allows each transmitting user to have a separate channel for communications. The radio stations on fm stereo are a good example of this. Each has its own frequency and occupies it continuously. This would be wasteful in packet radio which uses the channel only for brief periods. There are usually a set number of frequencies allocated for communications (such as 145.01 MHz, 145.03 MHz, and 14.103 MHz), and the user selects one before beginning.

Once a station starts transmitting over a certain channel, it usually stays on it until the communications session is over. This is known as static FDM because the stations do not switch between different frequencies during connection. Pure FDM operation does not provide a very versatile network.

TDM

TDM allows users to share a common channel without interfering with others. Each station transmits one after the other while users with no traffic stand by. The frequency is allotted by time to users with traffic to send; one station will transmit for a time and then

By Jonathan L. Mayo, KR3T, 3908 Short Hill Drive, Allentown, Pennsylvania 18104

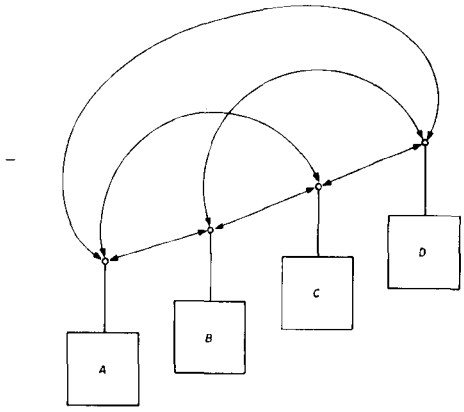


fig. 1. A diagram of a simple network in which all stations can communicate with each other directly.

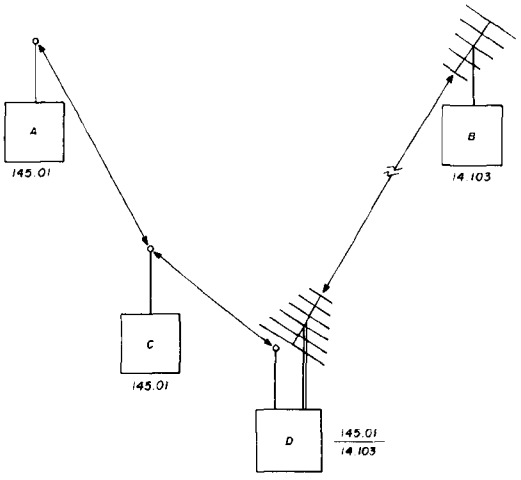


fig. 2. A diagram of a more advanced network in which a digipeater (Station C) and HF Gateway (Station D) are utilized to allow Station A on two meters to communicate with Station B on twenty meters.

be followed by another station. But, how does a station know when to transmit?

Three systems control the access of individual stations to a channel: random access, polling, and token passing.

random access

Packet radio uses random access. Individual stations follow specific rules to enter the system and must be able to determine if the channel is clear. The method used is CSMA/CD (Carrier Sense Multiple Access with Collision Detection). The station monitors (senses) the channel and checks to see if it is clear when it has traffic to send. If it is clear, the station transmits. A successful transmission is acknowledged by the destination station. If the channel is not clear, the station waits and transmits when it is. If two or more stations transmit at the same time a collision might occur. If this happens, the stations involved will receive no acknowledgment and must wait a random length of time to retransmit. Ideally, one station should have a shorter random wait, capture the channel first, and avoid another collision.

Packet radio uses both FDM and TDM, permitting operators to transmit and receive simultaneously. The channel (frequency) selected by FDM affects both the range and speed of data transmission. For example, channels in the 20-meter band have a large range but limited speed, and channels in the 2-meter band have a limited range but support much higher speeds.

TDM lets many operators share the same channel using CSMA/CD. For this to work, all stations on the channel must be within *hearing* range of each other.

Two Amateurs can occupy a higher frequency channel at the same time without interference as a result of Space Division Multiplexing or SDM. Stations in both California and Pennsylvania can transmit on 145.01 MHz simultaneously because the two signal paths do not cross. Factors in SDM are propagation, radiation patterns, and physical obstructions. Such effects are fairly constant and predictable on the VHF/UHF bands.

polling and token passing

In a polling system, a master station asks the others on the network channel if they have traffic to send. The channel is cleared by the master station for each to transmit in turn. Other stations must wait for clearance before they may begin transmission. Token passing is a similar form of TDM. In a token passing system, a single electronic *token* (a special binary sequence) is passed from station to station until it arrives at one with traffic to send. The station holds onto the token and transmits. The frequency stays clear because only the station with the token is allowed to transmit. When the station has finished transmitting, it passes the token to the next station on the network. Depending on network configuration, individual stations may communicate with each other directly or via the master station.

Polling systems lack popularity in packet radio because a master station with a fairly powerful computer and reliable communication throughout the network is needed to track users and their status. Packet users tend to drop in and out quickly and the radio links between stations vary in quality. To work effectively, polling network conditions must be regimented beyond what most Amateurs can provide. Another draw-

back is the amount of *overhead* (information that must be added to the basic data) required for destination routing.

protocols

Now that networking concepts have been covered, we can take a look at what makes packet radio work. How do individual stations know how to communicate with each other? What happens if data is sent but for some reason is not received? What if the data arrives garbled? How does a station know who data is for? How do digipeaters know which data to retransmit? The answers to these and other questions are found in the protocol.

Protocols define how data is packaged, what actions are taken under certain conditions, and when the actions are to be executed. The goal is to get data from its source to its destination as quickly, efficiently, and accurately as possible. Steps involved in using packet protocols follow.

Assuming a station can access the network, it must communicate its intention to transmit with a connect request. If the selected station is available, it will acknowledge the request and the two stations will connect. Once this happens, the information they send to each other is received error-free. When transmission is complete, the stations disconnect and are ready to contact others.

These and other processes are handled by protocols. *A protocol is a predefined series of steps followed to accomplish a task.* An illustration of a random access packet radio protocol is a normal 2-meter fm phone contact.

After first listening to see if the frequency is clear, call the station you want to contact. (AA3F AA3F this is KR3T. Do you read me?) Keep calling until a response is received or you decide to stop your tranmission. If he responds (KR3T this is AA3F. Go ahead.) you have established a connection. You would then transmit your information. (AA3F this is KR3T. Meet me at the mall in 5 minutes.) Give the receiving and sending stations' callsigns so AA3F knows the message is for him (The FCC likes this.). If AA3F acknowledges (KR3T this is AA3F. Roger.) the message was received. If AA3F doesn't respond in a reasonable length of time or asks for a repeat, send it again. End your transmission with a disconnect request (AA3F this is KR3T. 73.) and AA3F will respond (KR3T this is AA3F. 73.). You have just ended the connection and can place another call.

The same system applies to packet radio. A connection is established, information is transferred (or retransmitted when not received properly), and the connection is canceled. Keep in mind that this is a generalization. The protocol must be able to determine when information is received incorrectly, keep track of the connection status, translate data, assure device compatibility, and much more. A detailed look at protocol organization follows.

OSI/RM

Any network, packet or not, consists of many different components and functions: terminals, codings, voltages, error checking, connecting, relaying, and disconnecting. Networks become complex as their capabilities increase. The International Standards Organization (ISO) developed a reference model for networks. Known as the Open Systems Interconnection Reference Model (OSI/RM), it is designed to aid the information exchange between systems. They can be as simple as a current loop teletype or as complex as a worldwide network. *Open Systems* are those open for communications (such as a packet radio station). The OSI/RM separates network functions into levels based on their purpose.

Each OSI/RM level transfers data between the one directly above and below it. It interfaces at the point where data is transferred between levels. Data originates at the highest level and is passed down serially through each one. The information is processed by each level's protocol until it reaches the lowest implemented level. When the data is received, the path is reversed and it is sent back up the levels. Each level removes any additional information added by its equivalent at the sending station. When the data reaches the point of origin, it looks exactly as it did when entered into the network.

Each level operates independently. The only exchange of information between levels occurs at interface points. Every level has a protocol that may be changed without affecting the rest. The set of levels and associated protocols form the network architecture.

The flexibility and structure of the OSI/RM help to maintain compatibility between packet systems. The OSI/RM is divided into seven levels, each responsible for particular tasks and named according to its function. To refer to a level by number, use the word *level*, and when referring to a level by name, use the word *layer*. The seven OSI/RM layers are: physical, data link, network, transport, session, presentation, and application (see **fig. 3**).

Level 1 is the physical layer. It is responsible for the transparent transmission of bit streams across the physical interconnection between systems. This connection can be operated in either simplex, half duplex, or full duplex. The bits must arrive in the same order in which they were sent. Specifications for this layer include mechanical (plugs and dimensions), electrical (voltage and current levels), functional (the meaning of different voltage levels), and procedural (rules and sequences).

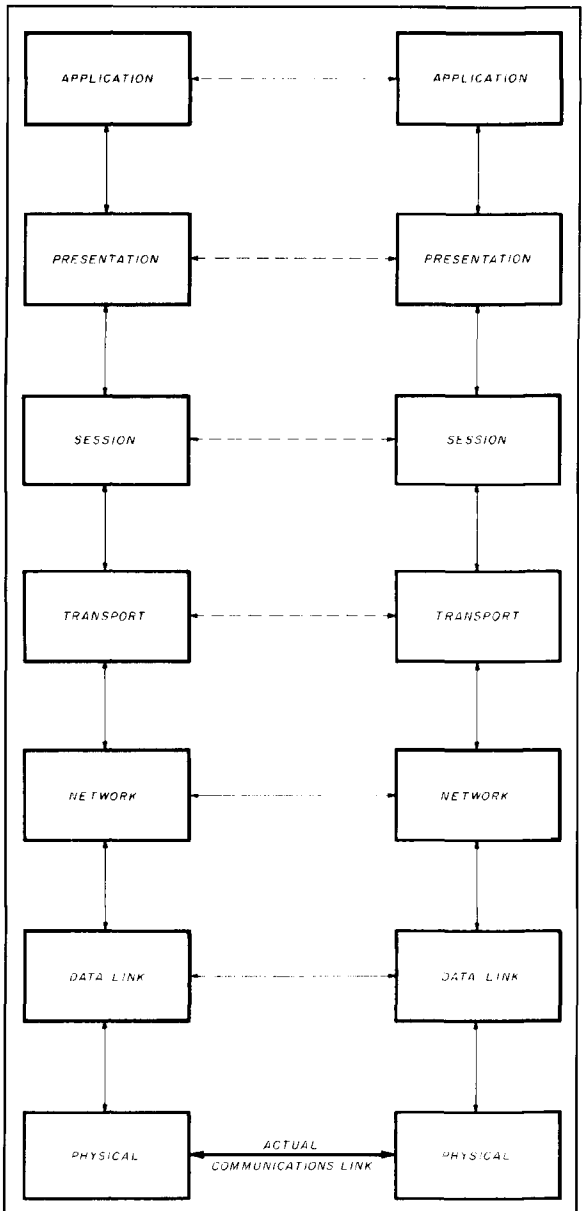


fig. 3. The levels of the OSI/RM. The solid arrows indicate layers that must be implemented at each node. The layers indicated by dashed arrows must be implemented only at the originating and destination nodes.

Level 2, the data link layer, shields the higher levels from the characteristics of the physical layer. It provides reliable transmission of data and should contain some form of error detection and correction. This layer must be independent of the data sent and may not alter it in any way. It must accept data and break it into segments for transmission. When the segmented data is combined with protocol information, a frame is formed. The frame must be delimited (allow for recognition of the beginning and end of the frame) and also be transparent (to be looked at only as a series of bits).

The frame is checked for accuracy upon reception and, if an error is found, retransmitted by the last station. Frames must be delivered in the same order they were sent. The standard level 2 protocol is HDLC (High-level Data Link Control). A subset of HDLC is used in most packet radio data link layer protocols.

The network layer, Level 3, provides transparent transfer of all data submitted by the transport layer, Level 4. Hence Level 4 is not directly involved in the connections between communicating systems. The systems may be connected point to point (direct) or have many nodes in the path. The network layer provides the routing functions needed to transfer data from one system to another; each system may act as a relay. Routing methods are not covered in the OSI/RM. Level 3 of the X.25 standard is one standard protocol for the network layer.

The transport layer arranges the information in the correct order if packets arrive out of sequence. It handles only communications between the origination and destination, and not relay stations that might be used by the network layer.

The session layer or Level 5 is responsible for initiating and terminating communications between stations on the network.

Level 6 is the presentation layer and handles data transformation (converting ASCII to Baudot), data and display formatting (a graphics terminal communicating with a hardcopy teleprinter), and syntax selection. If two systems are using incompatible devices, this layer handles the conversions necessary for data transfer.

In Level 7, the application layer, provision is made for proper operation of *application entities* or user-oriented software. Programs or computer functions controlled by the connected system are located here and fall under its protocol(s).

conclusion

We have looked into the operation of Amateur packet radio which uses a random access networking system. You have been introduced to protocols and their function. In Part 2 we will discuss protocols used in packet radio.

If you have any questions or comments, write to me at the address listed or leave a message on CompuServe; my User ID is 72276,2276.

Portions of this series are from my book, *The Packet Radio Handbook*, available from the *ham radio* Bookstore for $14.95 plus $3.50 shipping and handling.

ham radio

designing a station for the microwave bands: part 1

Easing your way into a new frontier

In many respects, the microwave bands represent a frontier for Amateurs; above the more familiar regions of VHF and UHF, they're often thought of as a magic domain. Like any physical frontier, they hold promise of untapped possibilities along with seemingly insurmountable barriers. Fascinating in attraction, they hold out hope for open space as the lower bands become full and, ultimately, overcrowded.

Although the microwave bands are often considered useful only for short range contacts where both stations are within line of sight of each other, microwave DX contacts are possible, often over paths which are anything but visual. One of the first surprises I encountered on 10 GHz was being able to clearly copy a 10-milliwatt transmitter by means of scatter off a mountain visible to both receiver and transmitter. The mountain was about 6 miles from both stations, and the direct path was blocked by another mountain. Antennas were a 4-foot dish on one end and a palm-sized horn on the other. Try that on VHF or below with similar sized antennas and equivalent power!

Such contacts aren't limited to scatter from mountains. Microwave communications over extremely long distances are possible via tropospheric and marine ducting *even when lower frequencies are not*. The current 10-GHz world's record of over 1000 miles bears testimony to this. Commercial jetliners offer a large enough (scattering) cross section to be usable for beyond-the-horizon contacts. Even more generally useful, the same tropospheric scattering that provides over-the-horizon communication at VHF is in effect at microwave frequencies. Moonbounce echoes with only a few tenths of a watt of transmitter power have recently been reported at 10 GHz.

At least part of the secret of these seemingly impossible modes of propagation lies in the high antenna gains available with physically smaller, and therefore realizable, antennas. Virtually all of the available transmitter power may be focused into a pencil-like beam. This can provide more signal to a distant receive antenna than would be possible with antennas of the same size at lower frequencies. This may mean, for example, that it would require 100 watts at 144 MHz to provide the same received signal level in 4-foot antennas that 0.1 watt can provide on 10 GHz!

Another part of the secret is narrowband operation. In the past, most Amateur microwave operation was accomplished with free-running, unstable oscillators. This method required wide receiver bandwidths to accommodate the transmitted signal. In addition, the receive local oscillator was often the same one used on transmit, which further increased the necessary bandwidth. While this approach was simple, signal-to-noise ratios were degraded by the additional noise present in the wider bandwidths. Reducing communications bandwidth from, say, 300 kHz to 3 kHz provides the same improvement in signal-to-noise ratio as increasing transmitter power from 1 watt to 100 watts — i.e., 20 dB.

Admittedly, there are difficulties in building and operating an Amateur station in the microwave bands,

By Glenn Elmore, N6GN, 3528 Deerpark Drive, Santa Rosa, California 95404

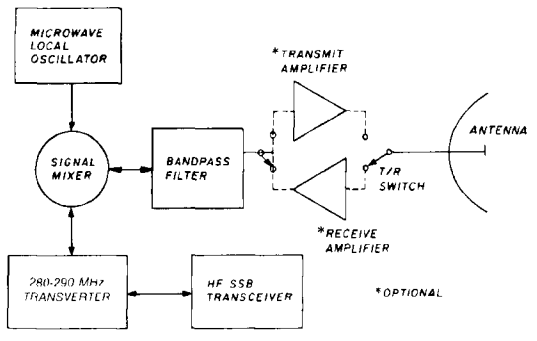


fig. 1. Microwave SSB is generated by converting a 20-30 MHz SSB transceiver first to 280-290 MHz and then to the microwave band using a microwave LO and mixer. A microwave bandpass filter removes unwanted mixing products.

but the excitement of these new regions and the chance for new records and discoveries certainly should draw some of us to further exploration.

As one goes higher in frequency, the number of components that provide gain and power is limited. In addition, maintaining stable and accurate frequencies as well as pointing high-gain antennas accurately are problems to be overcome. The point-to-point nature of microwave DX tends to reduce the likelihood of random contacts. "Round table" QSOs with many stations in different locations may require innovations in Amateur networking, but progress in these areas is currently being made at lower frequencies as digital Amateur radio progresses. The store-and-forward bulletin boards and network nodes currently being used in Amateur packet radio are steps toward a more complete information handling structure. Increased traffic over these channels requires higher data rates and more bandwidth becomes necessary. As our channels support higher information rates, digitized voice and other linear modes can be used. The available spectrum and point-to-point nature of microwave DX links make them ideal for such operation. As Amateur packet radio becomes increasingly popular, implementation of high-speed microwave "backbones" for long-distance cross-country communication becomes an attractive possibility.

design approach

This article describes one approach to designing and implementing a station for the Amateur microwave bands (as well as the two highest UHF bands, 1296 and 2304 MHz). The intent is to promote interest and show how to build a station that can provide all-mode contacts over significant distances. CW, SSB, and NBFM are obvious initial choices, but digital and video modes can be used as well, since the entire system supports linear signal frequency translation.

This open-ended approach minimizes complexity by taking advantage of readily available components and equipment. The intent is simply to demonstrate a practical way for more Amateurs to get on the microwave bands.

The bulk of this series focuses on generation of stable and precise local oscillator signals, since this is a primary hurdle that must be crossed for any narrowband operation at microwave frequencies. The local oscillator, a mixer, and an antenna are the minimum requirements for converting low-frequency Amateur transmitters and receivers for microwave operation.

Real communications over significant distances are indeed possible with this minimal station. The basic station doesn't have to be expensive. Receive preamplifiers and transmit amplifiers may be added at very little cost, and the recent availability of low-noise amplifiers in the 4-GHz range makes a good low-noise, moderate-power (by microwave standards) station actually affordable. QSOs over hundreds of miles are possible with such equipment and just a small, reasonably priced dish antenna. For less than the cost of a 2-meter fm transceiver, one may assemble a station capable of providing microwave DX and the excitement of participating in the exploration of still-uncharted regions of the radio spectrum. A block diagram for generating microwave SSB is shown in **fig. 1**.

A secondary goal of this article is to demonstrate a way to put a high-performance station on the microwave bands with as little test equipment as possible. Wherever possible, rf technology replaces complex microwave hardware. I've tried to use commonly available parts wherever possible, and kept the number of pc boards to a minimum by the use of common circuits. Only two microwave circuits, the mixer and PLL downconverter, have to be built, since the oscillator — a Gunnplexer™, for example — can be obtained commercially or as surplus (look for motion detectors and automatic door openers). Except for these, the entire station is assembled from standard VHF or lower frequency components and circuits.

I'd encourage anyone interested in getting on the microwave bands to seek out other interested Amateurs. Small users groups can be a great help in getting started and maintaining enthusiasm. They're also a good way to share not only measurement equipment, but expertise.

local oscillator

As shown in **fig. 1**, the basic blocks for a microwave station are the signal mixer, a bandpass filter to

Table 1. Combinations of a few basic reference signals allow great flexibility in generating phaselocked microwave signals. Combinations using a 1010 MHz reference allow access to every amateur microwave band, using either a 280-290 MHz or a 420-440 MHz SSB i-f.

Reference signals

ref osc frq = (harm x ref) ± PLL i-f

10_{std}	quartz standard in proportional oven
100_{ref}	100_{ref} = 10 x 10 std + 0 (decade divider instead of i-f)
150_{ref}	3 x (100_{ref} / 2)
20_{ref}	100_{ref} / 5
30_{ref}	3 x 10_{std}
10_{ref}	20_{ref} / 2
40_{ref}	20_{ref} x 2
8_{ref}	40_{ref} / 5
330_{ref}	(3 x 100_{ref}) + 30_{ref}
990_{ref}	(10 x 100_{ref}) − 10_{ref} or 3 x 330_{ref}
992_{ref}	(10 x 100_{ref}) − 8_{ref}
1008_{ref}	(10 x 100_{ref}) + 8_{ref}
1010_{ref}	(10 x 100_{ref}) + 10_{ref}

Microwave Local Oscillators

Band	1st LO = (harm x ref) ± PLL i f	SSB i-f	hf SSB dial (260 MHz 2nd LO)
1296	1008 = 1008_{ref} directly	288 MHz	28 MHz
	1010 = 1010_{ref} directly	286 MHz	26 MHz
2304 H*	2016 = 2 x 1008_{ref}	288 MHz	28 MHz
2304 H	2020 = 2 x 1010_{ref}	284 MHz	24 MHz
L	2020 = 20 x 100_{ref} + 20_{ref}	284 MHz	24 MHz
3456 H	3030 = 3 x 1010_{ref}	426 MHz	
L	3020 = 30 x 100_{ref} + 20_{ref}	436 MHz	436 MHz SSB
L	3020 = 3 x 1010_{ref} − 10_{ref}	436 MHz	436 MHz SSB
5760 H	6048 = 6 x 1008_{ref}	288 MHz	28 MHz
5760 H	6060 = 6 x 1010_{ref}	300 MHz	
L	6020 = 60 x 100_{ref} + 20_{ref}	280 MHz	20 MHz
L	6020 = 6 x 1010_{ref} − 40_{ref}	280 MHz	20 MHz
10368 H	10080 = 10 x 1008_{ref}	288 MHz	28 MHz
10368 L	10080 = 10 x 1010_{ref}^{6} − 20_{ref}	288 MHz	28 MHz
24192 H	23760 = 24 x 990_{ref}	432 MHz	432 MHz SSB
24192 L	23760 = 24 x 992_{ref} − 48	432 MHz	432 MHz SSB
24192 L	23910 = 24 x 990_{ref} − 150_{ref}	282 MHz	22 MHz
L	23910 = 24 x 1010_{ref} − 330_{ref}	282 MHz	22 MHz

remove unwanted mixing products, and the microwave local oscillator. Transmit and receive amplifiers are optional. Of these blocks, the local oscillator is probably the most complex. The problem of generating a stable local oscillator in the microwave bands may be solved in more than one way. Certainly an obvious method is to adopt the same techniques used at lower frequencies and traditional in Amateur VHF and UHF construction. That is, one may simply start with a high quality quartz oscillator — perhaps in the 100-MHz vicinity, since crystal oscillators there can have good spectral purity — and multiply up to the final microwave frequency selected. One problem with this is the necessity of including an active device and filter in each harmonic stage. If too high a harmonic number is used, it may be difficult to separate the preferred harmonic from the undesired ones around it. Even if suitably high *Q* filters are available, the extra complexity and amplifier power necessary to generate sufficient energy to operate a mixer is undesirable. This approach also isn't very versatile, since modifying oscillator fundamental frequencies, not to mention a whole string of harmonic filters, makes significant QSY extremely difficult. In addition, signal levels and multiplier stage gains need to be controlled to avoid multiplying broadband noise and degrading the ultimate microwave signals.

One alternative to frequency multiplication is to directly phase lock a microwave oscillator with a phase-locked loop (PLL). This is particularly interesting because when pushing any active device to its upper frequency limit, an oscillator may be built even when frequency multipliers and amplifiers aren't possible. A phase-locked oscillator may be used to produce a signal at frequencies where few active devices are available. Since suitable oscillators are readily available both commercially and on surplus markets, phase lock is an attractive possibility for Amateur operation that requires a minimum of microwave equipment construction.

Normally, to phase lock an oscillator, a signal that's a sample of the oscillator is compared to a high-stability reference signal. A loop amplifier is then used to steer, or "lock" the oscillator in step with the reference signal. A block diagram for phase locking an oscillator is shown in **fig. 2A**. The "phase sample" may be the oscillator signal itself, a frequency-divided or a frequency-converted version of it, *as long as phase information is retained*. Using the oscillator signal itself would require that the reference signal already be the desired stable signal. Using a divided signal would require dividers that operate at the oscillator frequency, but microwave frequency dividers aren't yet Amateur junk box items!

In its simplest form, frequency conversion presents the same disadvantage as using the oscillator signal directly — a precise microwave signal must already be available. However, it's possible to use a harmonic mixer to downconvert the oscillator signal (see **fig. 2B**). Such a mixer mixes the oscillator signal with a harmonic of a much lower frequency reference. This lower frequency reference signal may itself be produced by PLL techniques.

If phase lock is achieved by harmonic downconversion, the phase comparison may be accomplished at low i-f frequencies where gain is easy to come by and measurements are far easier to perform. Additionally, the harmonic converter need not have particularly low conversion loss, since only a reasonable signal-to-noise ratio is sufficient, the absolute signal level can easily be modified with i-f amplifiers. This is in contrast to harmonic multiplication, which requires enough drive at each stage to drive the active device or mixer into its nonlinear region. Step-recovery diode multipliers often need several hundred milliwatts of drive to function properly. Harmonic downconverters may need only 10 to 50 milliwatts of lower frequency drive, a much easier proposition. Additionally, phase-locked oscillators don't usually require filtering to remove unwanted signals as do multiplied oscillators, as long as the reference frequency components are suitably reduced by the loop filter.

Any available microwave oscillator may be used as long as a means of electronic tuning *that will allow correcting the frequency over a range which is larger than the drift caused by mechanical and environmental factors* can be found. Many Gunn diode oscillators may be tuned by slight adjustments to their power supply voltage. Other oscillators, such as the Gunnplexers made by M/A-Com, have an electronic tuning input. The PLL bandwidth must also be sufficiently high to clean up the oscillators' instabilities acceptably. It must be possible to modulate the microwave oscillator at frequencies a few times higher than this loop bandwidth for good loop stability. The bandwidth is easily adjusted by changing the PLL loop parameters, and usually something in the tens of kHz area is adequate. Because any local oscillator must be stable and accurate, the PLL is automaticlly a suitable choice in this respect. If all oscillators in a system can be referenced to one precision (preferably ovenized) reference oscillator, the best in frequency stability and accuracy may be obtained.

common oscillator circuits

After many years of VHF and UHF construction, there are two kinds of circuits I've gotten tired of building: one is power supplies (especially those with tubes) and the other is local oscillator/multiplier strings. Although using a PLL can simplify local oscillator con-

struction, there are several microwave bands, and it's best to avoid duplication of circuits as much as possible. To simplify multiband stations, many microwave enthusiasts are adopting a scheme using a 288-MHz SSB/CW i-f and local oscillators derived from a 1008-MHz precision source. All of the Amateur microwave bands except 24 GHz may be reached by mixing either 288 MHz or 432 MHz with a harmonic of 1008 MHz and selecting the appropriate sideband.

I've chosen a modification of this approach that uses 1010 MHz and a 280- to 290-MHz VHF intermediate frequency. Allowing slight deviation of the signal i-f from 288 MHz can also allow the MHz digit on the hf signal source to indicate correctly. For example, for operation on 2304 MHz, the hf transceiver is tuned to 24 MHz, giving an i-f of 284 MHz. This signal mixed with two times 1010 MHz gives 2304 MHz, and the MHz digit of the hf rig displays the MHz of the output frequency correctly. Since many of the newer transceivers will operate in transverter mode over 20 to 30 MHz, this approach seems to be suitable.

Table 1 shows some alternatives for generating signals on the microwave calling frequencies using this phase-locking approach. The reference signals are all derivatives of the 10-MHz standard oscillator. Phase lock is obtained by mixing a harmonic of a reference signal with the local oscillator to produce a PLL i-f frequency. This PLL i-f is then locked to a reference signal, producing a phase-locked local oscillator signal which can then be used to convert the 280- to 290-MHz VHF i-f to and from the preferred microwave band. The VHF i-f is generated using a 260-MHz phase-locked LO and the 20- to 30-MHz range of the SSB transceiver.

Also shown are some more traditional multiplying approaches for achieving a microwave LO.

Notice that the 1010-MHz phase-locked approaches all provide correct readout of the MHz digit of the SSB source. This may be of little concern for operation on only one microwave band, but since one LO system can effectively put you on all the microwave bands, frequency confusion in the heat of a contest may be something to reckon with!

The additional flexibility of the PLL i-f also provides access to the 24-GHz band. If this band seems esoteric, I'd like to point out that a 24-GHz oscillator with a built-in mixer diode is available for approximately $50. It may be possible to phase lock and mix for the receive i-f all in one diode, eliminating any other microwave hardware! Similar oscillator/mixer modules, designed for radar "gun" use, are available for 10 GHz.

preparing the 10-GHz station

The approach just described, which can be used either directly or with some modifications to get on all of the Amateur bands — affords a great deal of commonality in phase-lock circuitry. It's possible to lay out one circuit board that can be configured for almost every variation required for any of the locked loops. (This is important to avoid the power supply syndrome mentioned above!) Standard ECL integrated circuits and commonly available operational amplifiers are all that's required except for the harmonic downconverters. Adding another microwave band generally requires only an oscillator, a harmonic downconverter, and an additional phase-lock pc board. Also, significant frequency change within a band is often accomplished by simply selecting a different reference signal and changing the coarse frequency adjustment of the microwave oscillator.

In all cases, from 10 MHz to microwave, the best "raw" oscillator should be used. At 10 MHz, the long-term stability of the standard is the desired characteristic. The loop bandwidth of this PLL is kept low so that the poorer phase noise contributions of the 10-MHz standard won't contaminate the less accurate but cleaner 100-MHz quartz oscillator. At 1010 MHz, the operating *Q* of the resonator and the resulting oscillator spectral purity is kept as high as possible. This oscillator is really rather stable when unlocked. Measurements over a period of several days and at a relatively constant temperature showed only a few

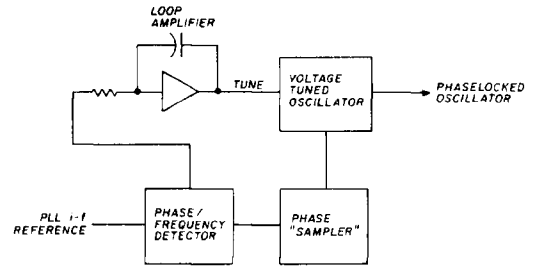


fig. 2A. A simple phaselocked loop (PLL) holds a voltage tuned oscillator (VTO) in constant phase relationship to a reference signal. A signal which is a representative "sample" of the VTO's phase must be provided.

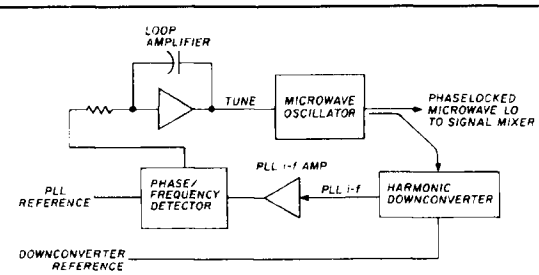
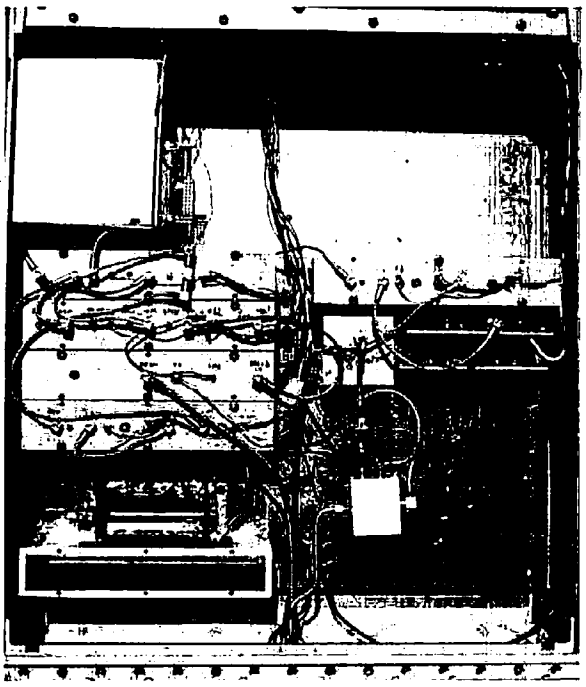


fig. 2B. Phaselocked microwave source block diagram.



Phaselocked 10080 MHz local oscillator and 288 MHz SSB transverter. 10 MHz standard in upper left.

tens of kHz drift. The spectrum of this oscillator when locked is essentially a replica of the tenth harmonic of the 100-MHz crystal oscillator. This feature, combined with simplicity of construction, makes this an effective solution to the problem of generating a clean and stable GHz signal.

A multiplier/filter string could be used to generate this 1010-MHz signal instead of the direct phase-locked approach. This would probably require either an ovenized 101-MHz oscillator or dividing by 101 and phase locking to a 1-MHz reference derived from a master station oscillator. In that case, sufficient filtering at 1010 MHz must be provided to reduce spurious signals to -70 dBc or less. The direct phase-lock approach provides a clean spectrum that's directly attributable to the high-*Q* resonator, as long as loop bandwidth is small enough to keep reference frequency sidebands sufficiently low. The only other spurious signals present are multiples of the 100-MHz signal from the harmonic downconverter. These signals, predominantly the odd harmonics at 900 MHz and 1100 MHz, are attenuated by the isolation between the 1010-MHz buffer amplifiers.

The microwave oscillator may be whatever you can get or build. However, using Gunn diode oscillators (such as the M/A-Com Gunnplexers) results in a 10.080-GHz signal that has as clean a spectrum as many hf transceivers on 20 meters. The resulting 10,368-MHz SSB signal is also of excellent quality.

#1 Source of PACKET Info

CTM

The Magazine

For Amateur Radio and Computerists

Why You Should Subscribe!

Read what our subscribers say!

It's in the fine print!

•*Your magazine is the finest innovation that I have seen in ham radio since 1953—except... maybe the all-solid state tranceiver.* **Carl Soltesz, W8PFT** • *...have most certainly received my money's worth in software...* **Michael Regan, K8WRB** • *...you have found a nice niche for CTM in packet... you have me getting interested...* **Charlie Curie, AD4F Chattanooga, TN** • *The packet computer info convinced me to subscribe.* **John Skubick, K8JS** • *Enclosed is my check for renewal of my subscription. I enjoy the down to earth and homey style of your magazine and the many fine computer articles...* **Andy Kosiorek, Lakewood, OH** • *I was both pleased and dismayed upon becoming acquainted with your magazine at HAM-COM. Pleased that I discovered your magazine—dismayed that I didn't long before now.* **Bill Lathan, AK5K** • *...CTM gives the finest coverage to packet radio that I have seen in any of the computer or amateur radio magazines. It would appear that CTM has just the right blend of packet amateur radio articles and computer articles.* **Barry Siegfried, K2MF** • *Of the three HAM magazines I received each month* **CTM** *is the only one I read from cover to cover and carry with me during my travels abroad. Most of the time it remains in that country.* **Buck Rogers, K4ABT**

U.S.A. $18.00 1 Yr—$10.00 6 Months (Limited Offer) $33.00 2 Yr
Mexico & Canada $32.00 1 Yr (Surface)
Other Countries (Air) $68.00 (Surface) $43.00 1 Yr
U.S.FUNDS ONLY
Sample Copy & Back Issues—$3.50

Mail to:
Circulation Manager
1704 Sam Drive
Birmingham, AL 35235
(205) 854-0271

Name _____
Call Sign _____
Address _____
City _____ **ST** _____ **ZIP** _____
Date _____
Signature _____

156

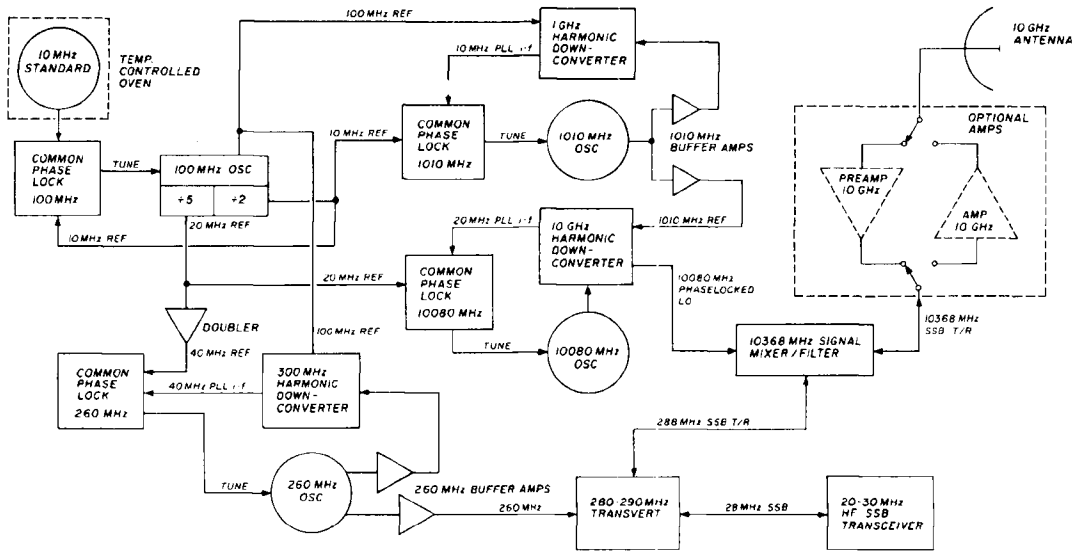


fig. 3. A precise 10,368 MHz SSB station can be made from only 5 oscillators and 4 nearly identical phaselock circuits. The PLL downconverters are similar in topology and easy to construct.

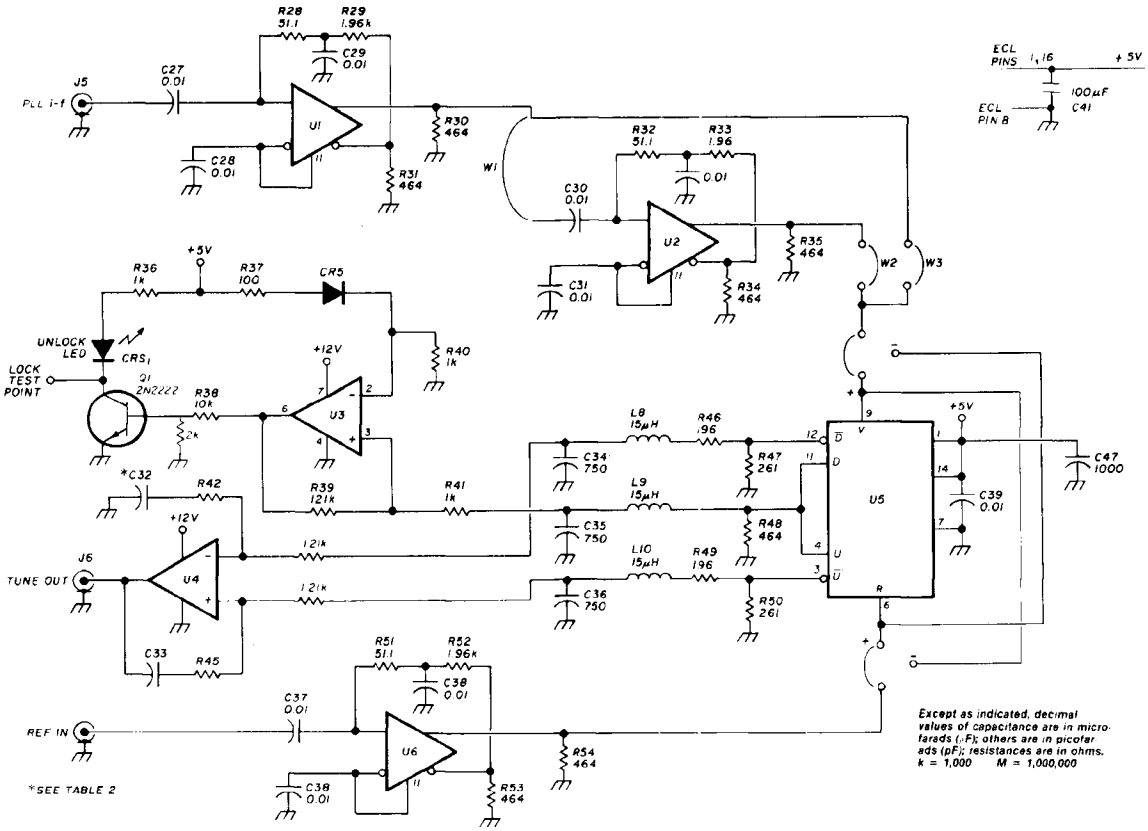


fig. 4. The common phaselock circuit uses inexpensive ECL and op-amp integrated circuits. Only 4 components and 2 jumpers need be changed for a great variety of different applications.

Gunn diode oscillators used as sources for automatic door openers have been tried with similar results.

Using this LO approach on 10 GHz is quite amazing. Even when out on a hilltop, once the oven for the 10-MHz frequency standard is operating at temperature, the hf transceiver can be set exactly to a scheduled frequency. When the another station calls, the SSB signal from a similarly phase-locked distant station is tuned correctly. A detailed system block diagram is shown in **fig. 3.**

order of construction

For those planning to build an entire 10-GHz station, construction of the 100-MHz oscillator and ECL dividers is a good place to start. If a 10-MHz standard is available, the phase-lock circuit may be built and the 100-MHz oscillator phase locked. If possible, a common pc board should be made and several boards loaded and tested. Then, building the 1010-MHz oscillator, buffer amplifers, and downconverter, and changing four components on one of the pretested phase-lock boards, will result in a precision 1010-MHz reference signal. Next, building the 260-MHz oscillator and locking it with another of the phase-lock boards and adding mixers and amplifiers produces the 280- to 290-MHz i-f transverter. At this point, both 1296 and 2304 are within easy reach by adding just a mixer (and amplifiers, if you wish). For 2304, an anti-parallel diode mixer just like the harmonic downconverters will suffice to get a signal on the band without even building a doubler or additional locked 2020-MHz oscillator. Inexpensive MMIC amplifier blocks can be used for transmit and receive amplifiers to produce a respectable 1296- or 2304-MHz station almost immediately. Finally, the 10,080-MHz LO is obtained by locking a Gunn oscillator with one more common pc board and the 10-GHz harmonic downconverter. Here again, one can immediately get on the band at the few hundred microwatt level by just adding the signal mixer. This mixer can even be built on the same Teflon™ pc board and at the same time as the harmonic downconverter. A simple bandpass filter for 10,368 MHz has already been discussed, and a two-stage amplifier will be described at the end of this article.

For those who want to get on the 10-GHz band as rapidly as possible, the flexibility of this phase-locked approach offers many choices. It is possible, for example, to get on 10,368 MHz SSB using only a 148-MHz SSB signal as the i-f. This can be done by generating a 1020-MHz signal instead of 1010 MHz for the microwave downconverter reference, simply by using a 20-MHz reference in that PLL and coarse tuning the resonator 10 MHz higher. Also, using a 20-MHz reference on the 10-GHz Gunn oscillator PLL gives 10 x 1020 MHz + 20 MHz = 10,220 MHz. 10,220 MHz LO + 148 MHz SSB = 10,368 MHz SSB. The 10,220-MHz LO could also be used with a 30-MHz wideband i-f to work other Amateurs in the area not yet on narrowband modes using 10,220/10,250 full duplex. SSB operation could be utilized by just changing to the 148-MHz SSB i-f. Notice also that reversing the reference and VCO inputs to the phase comparator allows locking on "the other side." In this last example, 10,180 MHz would result from such a reversal. Many combinations of reference frequencies and tuning directions are possible, and this versatility is an attractive aspect of this whole approach.

common phase-lock circuit

By taking a uniform approach to local oscillator generation, that of phase locking to a relatively low frequency reference, a great deal of commonality in circuit design is achieved. In fact, all four phase-lock loops used to generate 10,368-MHz SSB have identical phase detector, loop amplifier, and lock indicator schematics. Only the loop filter component values need to be varied to accommodate the differing oscillator characteristics. This is a great boon to construction, since one circuit board may be laid out which serves all four loops. The phase-lock circuit board uses ECL line receivers to amplify the reference and VCO inputs, phase detection is in a 12040-ECL phase comparator, and standard operational amplifiers are used in the loop amplifier/filter and phase-lock detect circuits. A schematic of the common phase-lock circuit is shown in **fig. 4.**

I made a common pc board that contained the phase-lock circuits, the 100-MHz oscillator and dividers, and the 1-GHz harmonic downconverter/PLL i-f amplifier. All this fits on a double-sided 3- x 6-inch board, and only the parts required for a particular function need be added. Normal VHF construction practices are followed, including good bypassing on the ECL logic, which is important since operation is from +5 instead of −5 volt supplies. The only circuit that operates higher than 100 MHz is the anti-parallel diode mixer, and the two diodes can be mounted right next to a coax connector to keep lead length to near zero.

I chose to use a large number of small coaxial connectors between circuits. This is more expensive, but it adds a great deal of versatility in changing reference frequencies, measuring signal levels, and so forth. For VFO control, any of the PLL reference frequencies may be substituted with a variable frequency reference as long as ECL logic levels are provided. This may be useful in testing or experimenting. Substituting the 10-MHz reference on the 1010-MHz PLL oscillator with a 10- to 11-MHz variable oscillator, for example, could give a variable 10,080- to 10,090-MHz microwave signal with the same stability as the tenth harmonic of the variable oscillator. This might be useful as a signal source for microwave testing.

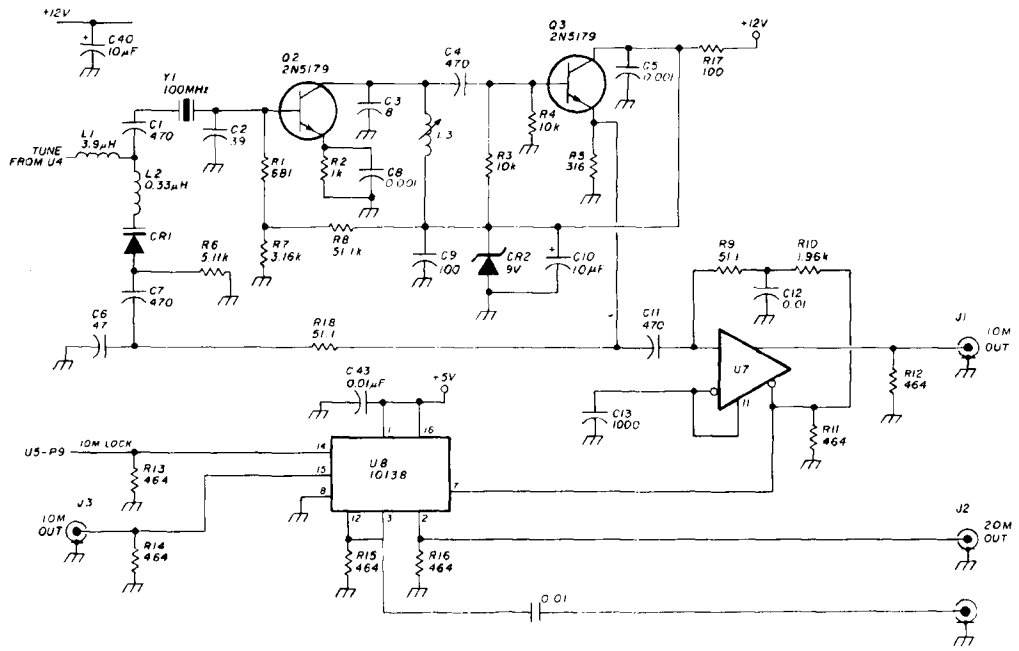


fig. 5. The 100 MHz crystal oscillator and divider circuits provide reference signals for generating all higher frequency signals. The oscillator itself can be locked to a precision 10 MHz frequency standard.

The PLL characteristics are modified by changing R42/R45 and C32/C33. This is necessary to provide different loop bandwidths and accommodate different oscillator tuning sensitivities. **Table 2** gives some values for some selected bandwidths and oscillators. For situations not listed, approximate values may be calculated. Referring to **fig. 6**:

$$A(s) = (K_d\ K_a\ K_v)/(N)$$

Where A(s) = loop gain at frequency *s*
K_d = phase detector sensitivity in volts/radian
K_a = loop integrator gain at *s*
K_v = oscillator sensitivity in radians/(volt sec)
N = frequency division of oscillator before phase detector

Component values can be calculated by first selecting a loop bandwidth and setting K_a to give unity gain at that frequency:

$$K_a = (N\ \omega_n)/(K_d\ K_v)$$

Where ω_n = loop bandwidth in radians/sec

(radians/sec = $2\pi f$ with *f* in Hz)

R_2 can be selected by R_2:
$= K_a\ R_1$

Next C can be selected by choosing $1/(R_2\ C)$ to be four or five times lower in frequency than the loop bandwidth to provide adequate loop stability.

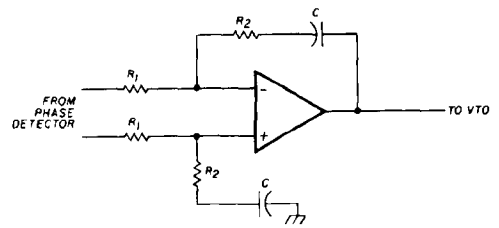


fig. 6. The loop amplifier (integrator) controls the characteristics of the PLL. Loop parameters are set by properly selecting component values. In this balanced configuration, each component appears twice.

$$C = 5/(\omega_n R_2)$$

As an example, let's assume we want to lock an oscillator with a tuning sensitivity:

$$K_v = 0.5\ \text{MHz/volt} = 3.1 \times 10^6\ \text{rad/(volt sec)}.$$

The 12040 phase detector has a

$$K_d = 0.13\ \text{volt/radian}.$$

Since we have no frequency division (a harmonic mixer is a *mixer*, not a divider), N = 1.

Suppose we want a 50-kHz loop bandwidth to "clean up" the oscillator. Then:

$$K_a = (1 \times 2 \times \pi \times 50{,}000)/(0.13 \times 3.1 \times 10^6) = 0.77$$

Since R_1 is fixed at 1210 + 196 = 1400 ohms.

R_2 = 0.77 x 1400 ohms or 1000 ohms

and

$C = 5/(2 \times \pi \times 50{,}000 \times 1000) = 0.015\ \mu F$

It is important for loop stability that both the oscillator and the op amp operate well below their roll-off frequency. For the oscillator, its tuning sensitivity should be constant to at least five times the loop bandwidth selected. In the case of the op amp, the product $K_a\omega_n$ should be no more than 10 to 20 percent of the specified gain-bandwidth. This specification will depend on the particular op amp used, but if ω_n is always selected to keep $K_a\omega_n$ below 1M radians/second, performance should be satisfactory. When in doubt about loop stability, design for a lower loop bandwidth; noise sidebands on the oscillator may be higher, but at least the loop will be stable!

100-MHz oscillator and divider circuits

A clean 100-MHz quartz oscillator is locked to a stable, though less spectrally pure, 10-MHz standard oscillator. In the event that a stable 10-MHz standard is not available, this oscillator may be operated unlocked, but the frequency accuracy and drift may not be as good as you would like for SSB and CW weak-signal operation, particularly on the higher bands. In any case, this 100-MHz reference may be built first and used for locking the higher frequency oscillators even without a 10-MHz standard.

Table 2. Typical loop amplifier component values for phaselocking the 10 GHz station oscillators. Other oscillator sensitivities can be accommodated by calculating values as demonstrated in the text.

Oscillator	100 MHz VCXO	1010 MHz	10,080 MHz Gunn Osc	260 MHz 2nd LO
Loop bandwidth				
f (Hz)	50	50k	50k	50k
Wn (rad/sec)	310	310k	310k	310k
VTO sensitivity, Kv				
MHz/volt	0.0002	0.5	3	1
rad/(volt sec)	1300	3.1M	19M	6.3M
Loop Gain, Ka	18	0.77	0.13	0.38
divide # N	10	1	1	1
R42/45 (ohms)	25	1.1	180	530
C32/33 (μF)	0.6	0.015	0.09	0.03

These values assume R43/44 = 1210 ohms and R46/49 = 196 ohms and
phase detector sensitivity, Kd = 0.13 volts/radian

A two-stage Pierce harmonic circuit is used with a UHF TV tuner varactor diode to allow frequency control. A variable capacitor may be substituted when no 10-MHz standard is used. An ECL line receiver is used to level shift and buffer this oscillator and drive the bi-quinary ECL divider. The divider output drives one input on the common phase-lock circuit (if used), the other input being provided by the 10-MHz standard oscillator. The loop parameters are set to give 10 to 100 Hz of loop bandwidth. The divide-by-five output of the 10138 divider provides a 20-MHz reference signal for use in the other loops. The 10-MHz ECL signal is also brought out. The schematic of this circuit is shown in **fig. 5**.

Beyond following the usual sound VHF practices, no special precautions need be taken in constructing this circuit. Whether or not 10-MHz standard is being used, it's a good idea to position components so that the entire oscillator circuit can be shielded and, if possible, thermally insulated to avoid frequency drift from ambient temperature change.

testing

If an oscilloscope, spectrum analyzer, or 100-MHz frequency counter isn't available, both the oscillator and divider circuits should be built at the same time. Then a 10-MHz WWV receiver or any receiver that tunes 10 MHz may be used to ascertain oscillation and division. Before trying to "close the loop" and lock the 100-MHz crystal oscillator, it's a good idea to check that the tuning range is from approximately 1 kHz below 100 MHz to 1 kHz above. This can be done by applying both 5-volt and 12-volt supplies and listening to the divider output at 10 MHz to see that the signal swings 100 Hz on either side of 10 MHz when a 2- to 10-volt tuning voltage is applied. Next, hook up the loop amplifier and the 10-MHz reference signal (from any source that is within this tuning range) and monitor the tuning voltage. If the loop locks correctly, the unlocked LED should extinquish and the tuning voltage should move between ground and the positive 12 volts as L3 is adjusted. At each end of that range, the unlocked light should light, indicating unlock due to an out-of-range 100-MHz oscillator. If a problem exists, make sure that the phase comparator inputs are correct, the connections marked " + " are being used, and recheck for wiring errors.

The second installment will cover construction of the 1010-MHz oscillator, harmonic downconverters for both 1 and 10 GHz and some circuits for biasing and driving the 10-GHz Gunn oscillators.

reference

1. Glenn Elmore, N6GN, "A Simple and Effective Filter for the 10 GHz Band," *QEX*, Volume 65, July 1987, page 3.

ham radio

radial line stub design

BASIC program helps determine microstrip circuit element

The radial line stub is a microstrip circuit element which provides a point of rf ground potential at a particular frequency, based on the physical parameters of the substrate and the geometry of the stub. Particularly useful in designing mixers, bias circuits, and doublers in the microwave frequencies, it is relatively short compared to quarter-wave stubs and has a broader resonance, but provides a precisely located input. **Figure 1** illustrates two examples of the use of the radial line stub.

simple program solves for dimensions

Computer-Aided Design (CAD) techniques have been used to design these stubs for Amateurs.

Equation 1 is an algebraic expression yielding a linear approximation of the CAD segmented microstrip model, solved for the outer radius, R_L for either 60- or 90-degree stub angles.[1]

$$log\ R_L = A\ log\ (\sqrt{E_R} \cdot f) + B\ log\ H + C\ log\ R_S + D \quad (1)$$

Note: R_L = *RL* (in listing)
E_R = *ER* (in listing)
f = F (in listing) R_S = RS (in listing where R_L is the long radius of the stub in meters; A, B, C, and D are constants, which are functions of the stub angle; E_R is the dielectric constant; *f* is the frequency in GHz; H is the dielectric thickness in meters; and R_S is the short radius in meters.

The BASIC program, RAD-STUB, (**fig. 2**) gives the value of R_L, the outer radius. The required parameters are the frequency, dielectric constant of the substrate and its thickness, and an estimate of the inner radius, R_S. The result approximates the resonant frequency within 1 to 2 percent for 60-degree stubs, which are the most frequently used.

The BASIC program is straightforward. While it was written for the IBM PC, it should run with other BASIC languages if modifications for screen, input, and exponents are made. **Line 9** clears the screen and removes the function keys from the PC screen. **Lines 30-60** may have to be split into print and input state-

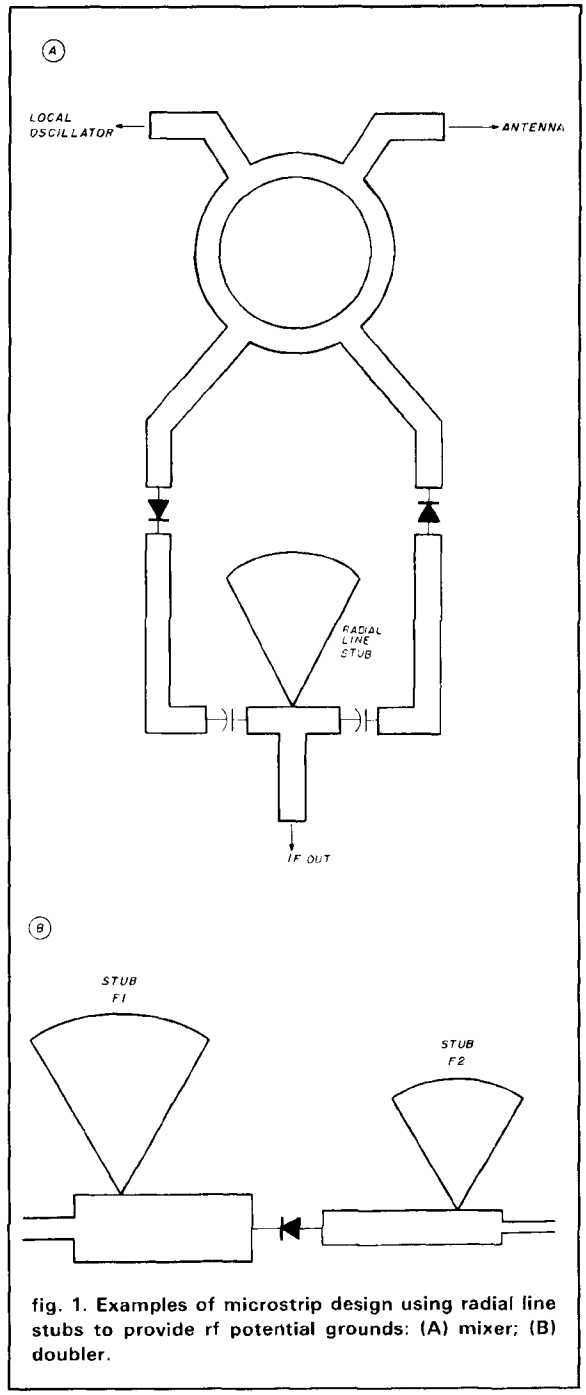


fig. 1. Examples of microstrip design using radial line stubs to provide rf potential grounds: (A) mixer; (B) doubler.

By George W. Allen, N1BEP, 731 Coral Drive, Cape Coral, Florida 33904

```
9 CLS: KEY OFF
10 PRINT "          ********** RADIAL STUB DESIGN **********"
20 REM                          by George W. Allen, N1BEP
25 PRINT: PRINT
30 INPUT "Frequency, gHz (0.3 - 30)";F: '          ***  F=Frequency, gHz
40 INPUT "Dielectric constant";ER: '               ***  ER=Dielectric constant
50 INPUT "Substrate thickness, inches";H: '        ***  H=Substrate thichness
60 INPUT "Inner radius, inches";RS: '              ***  RS=Inner radius
70 H=H*.0254: RS=RS*.0254
80 PRINT "Stub angle 1-60, or 2-90 degrees";
85 INPUT K: '                                      ***  K = STUB ANGLE
90 ON K GOTO 100,120
100 A=-.8232: B=.0572: C=.1169: D=-.8052
110 GOTO 130
120 A=-.851: B=.0614: C=.0877: D=-.8695
130 L=LOG(10)
140 E=A*LOG((ER^.5)*F)/L + B*LOG(H)/L + C*LOG(RS)/L + D
150 '                                              ***  E=LOG(RL)
160 RL=10^E: RL=RL*39.370079#: '                   ***  Meters to inches
170 PRINT: PRINT "Long radius is";
180 PRINT USING "###.####";RL;
190 PRINT "  inches"
200 END
```

fig. 2. Basic program for radial line stub design.

```
(A)   Frequency, GHz (0.3-30)? 10
      Dielectric constant? 9.8
      Substrate thickness, inches? 0.25
      Inner radius, inches? .002
      Stub angle 1-60, or 2-90 degrees? 1
      Long radius is 0.0743 inches

(B)   Frequency, GHz (0.3-30)? 1.296
      Dielectric constant? 2.3
      Substrate thickness, inches? .06
      Inner radius, inches? .002
      Stub angle 1-60, or 2-90 degrees? 1
      Long radius is 0.7625 inches
```

fig. 3. Program results for (A) 10 GHz and (B) 1.296 GHz.

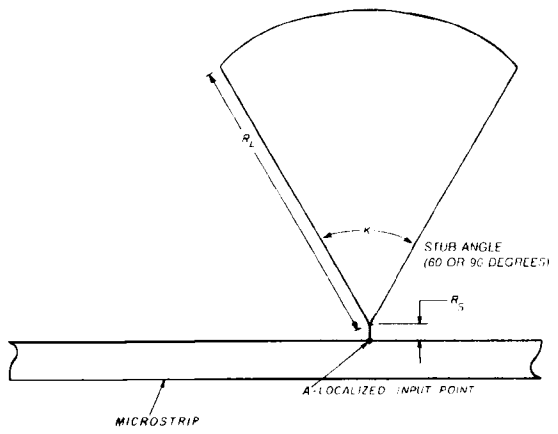


fig. 4. Mixer stub geometry, top view.

ments. **Lines 140** and **160** use the caret for exponentials. **Line 180**, which truncates the printout to limit useless digits, may be just a PRINT command. The constants for 60 and 90 degrees, **lines 100** and **120** are based on metric units, although common usage is in inches for printed circuit material; **lines 70** and **160** accommodate the conversion. The equation is in logarithms to the base 10, so **lines 130, 140** and **160** convert to natural logarithms and back to solve the equation.

examples

Two examples of the program's output are shown in **fig. 3**. The limits of the approximation are from 0.3 to 30 GHz, but the result becomes quite broad at the high end. The dielectric constant values should lie between 2 and 15 for the values of the constants used in the approximation. The results are consistent with the values of dielectric constant in practical materials at given frequencies, and with the ability to measure and etch printed circuits at these small dimensions. **Figure 4** illustrates a top view of the stub geometry.

summary

A BASIC program solves the approximate equation for the dimensions of the geometry of a radial line stub for the frequencies between 0.3 and 30 GHz for values of dielectric constant from 2 to 15.

reference

1. H.A. Atwater, "The Design of the Radial Line Stub: A Useful Microstrip Circuit Element," *Microwave Journal*, Volume 28, No. 11, November 1985.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

"the greatest little radio magazine in the world"

VHF? Yes. Single sideband? Yes. Beam Antennas? Yes. Microwaves? Yes. Propagation? Yes.

The year was 1930. America was in the grips of the Great Depression. The unemployment rate, during that harsh winter, was over 30 percent. Wall Street was in a panic. The future looked bleak, indeed.

From the perspective of today, the world we knew in 1930 is hard to imagine. No one had heard of Ronald Reagan or Olivia Newton John. No homes contained TV sets, VCRs, air conditioners, or electric blankets. No one had heard of atomic meltdown, jet aircraft, coffee machines, water beds, hand calculators, word processors, or microwave ovens.

Young men, with little money but plenty of time on their hands, slowly grew interested in shortwave radio. For a dollar or so, an old battery radio could be bought, stripped down, rebuilt into a two-tube shortwave receiver. A second-hand car battery would provide filament power, and B-batteries were cheap.

Once the set was completed, the builder had the world at his fingertips. But it didn't come easy. Where was the information he needed to build a two-dollar shortwave receiver? And when it was built, what could you hear? What was going on in the world of shortwave radio?

meet Hugo Gernsback

Into the growing hobby stepped a giant with an imposing track record of accomplishing feats that others



fig. 1. Early issues of "Short Wave Craft" magazine were full of exciting, new ideas. Feature articles on short wave medical applications (diathermy), "moonbounce", and inexpensive phone transmitters guaranteed high interest among would-be hams for each new issue. Articles by Dr. Alfred N. Goldsmith and Dr. Willis Whitney satisfied the more technical readers.

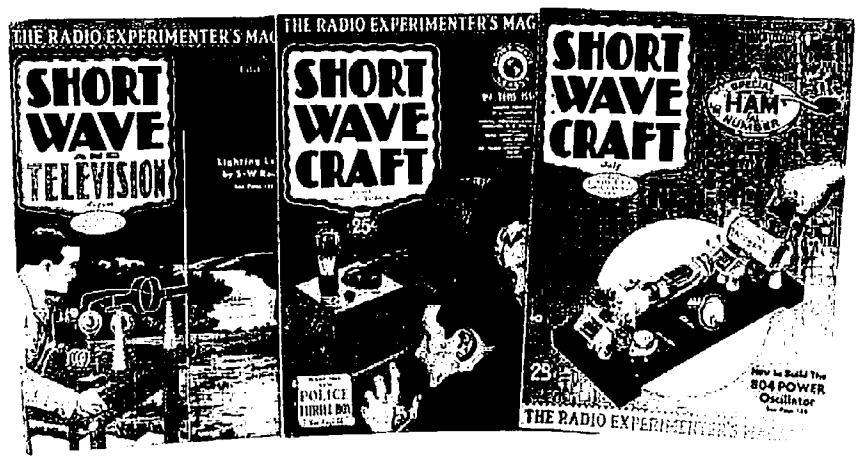


fig. 2. As "Short Wave Craft" matured, it appealed more to the amateur market. Covers by "Paul" (above), who did the covers for "Amazing Stories" were a feature of some issues. Interest in shortwave listening seemed to be dropping off, so the magazine catered to radio hams until World War II.

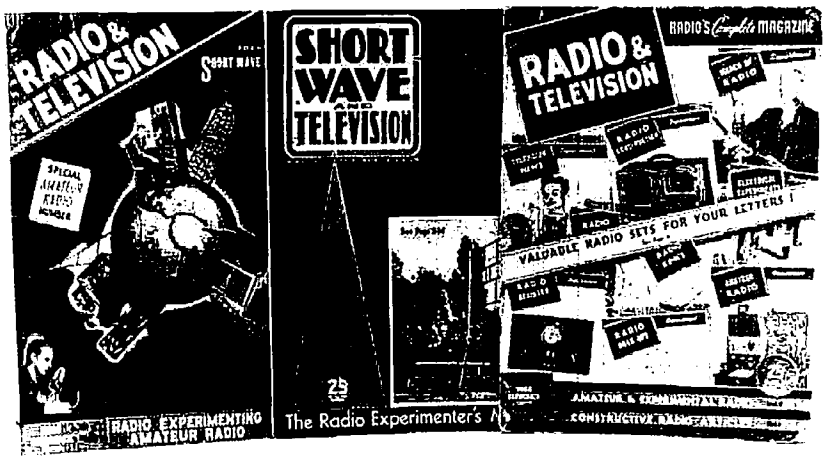


fig. 3. The "Short Wave Craft" magazine changed it name to "Radio and Television" in 1940, after a brief existence as "Short Wave and Television." But by 1941 the magazine was fragmented, vainly trying to appeal to various radio hobbyists. After the war, the magazine combined with other Gernsback publications and eventually became "Radio Electronics."

thought impossible. He had established the world's first radio store and sold the world's first radio magazine. His name, Hugo Gernsback, was well known as that of the publisher of science fiction magazines. Now he was going to turn his hand to publishing the greatest magazine in the world for shortwave enthusiasts!

Short Wave Craft magazine

The first issue of *Short Wave Craft* magazine hit the newstands in 1930 at the exorbitant price of fifty cents. Though the pricing was a blunder, the magazine was an immediate success; the cover price soon dropped to a quarter. Bursting with new ideas and exciting circuits that a high-school lad could understand, the magazine quickly became a focus of interest among the younger generation. It opened the door not only to shortwave radio, but to Amateur Radio as well (figs. 1, 2, 3).

While a certain proportion of the articles sailed over the heads of most readers — for example, those about sideband transmitters (see fig. 4), inverted speech for transatlantic telephony, and curtain array antennas — each issue had enough down-to-earth contruction material to satisfy beginning hobbyists.

"afternoon radio DX"

One of the greatest attractions of *Short Wave Craft* was the number of "do-it-yourself" articles. Ham radio was going through a population explosion, with ranks increasing from slightly over 20,000 to over 34,000 in only two years! Most of the new Amateurs were high-school boys who had plenty of enthusiasm — all they needed was information. As the magazine pointed out, a second-hand battery-operated broadcast receiver bought for 25 cents or less could provide everything needed to get on the air with a receiver and a phone transmitter!

The receiver was a two-tube job (fig. 5). Either type 30 or type 201A tubes could be used. All of the parts came from the defunct battery set. A passable pair of headphones cost less than a dollar, and doorbell batteries could be had for next to nothing.

The transmitter circuit (fig. 6), however, was another matter. The big stumbling block was the microphone. Everything else came from the old broadcast receiver. If you knew the right guys, you could get a "mike" from a telephone for fifty cents. (They were probably "liberated" from pay phones, but it was wise not to ask too many questions.)

Once all the parts were assembled, a day's work would produce a breadboard transmitter that would work in the 160-meter band. It ran about 20 watts input, which, with a 120-foot antenna, provided a range of about 50 miles.

This was a lot of fun! The band came alive about 3:30 in the afternoon, when everybody started coming home from high school. From that time, until just before dinner, the band was yours! These wobbly, little phone

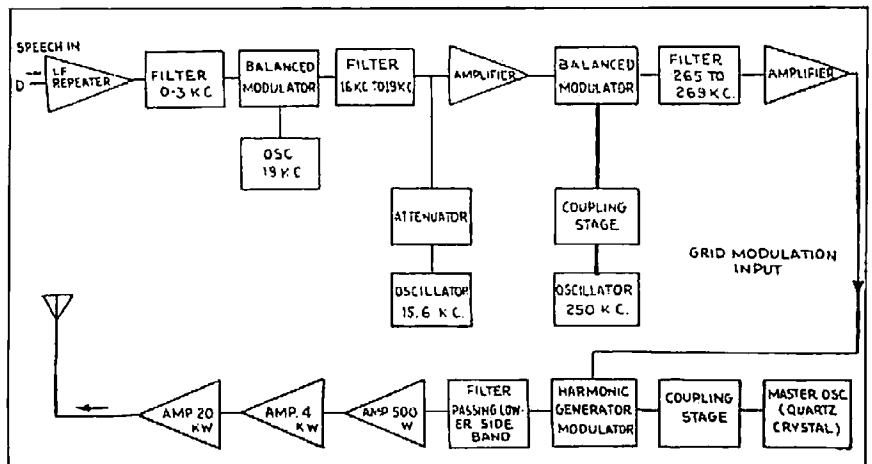
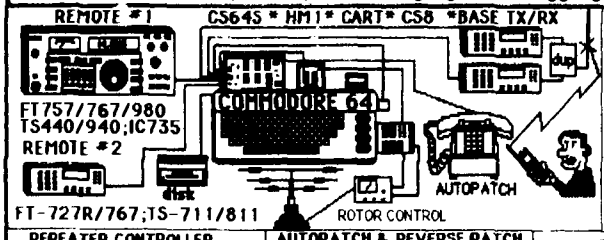


fig. 4. A look at single sideband in 1930, when it was hardly a household word! Because of the problem of building a high-Q sideband filter, the early transmitters started out with a balanced modulator in the 20 kHz to 50 kHz range. This circuit shows sideband generation in the 16-19 kHz range, with additional mixing to 265 kHz.

*** Super Comshack 64 ***

Programable Repeater Controller/HF & VHF Remotes/Autopatch

Rotor Control/Voice;CTCSS;2 Tone Paging/User Logging/Unlimited Vocabulary



The **CS64S** is the most advanced control system available at any price. Total control of your ham shack/club station. Each user has individual access codes and privilages granted by the control op. All user's logged to disk &/or printer. HI/lo priority patch & security/monitor/lock modes. Talking Packet BBS input **soon.**

REPEATER CONTROLLER
*Change all variables remotely
*Programeble synthesized voice
*Program mail box or select ID tail mess with touchtones from HT
*Alarm clock & auto excute mode
*Macro commands/user **logging**
*Individual user access codes
*Code practice & voice readback
*Multifunction voice alarm clock

H.F. REMOTE #1
***20 Macro mem**/auto mode sel.
*Scan up/down sel. rate or step
*Voice ack. all control commands

AUTOPATCH & REVERSE PATCH
***1000** (**18** digit)tel. #'s stored
***1000** calls paged/CTCSS & 2 tone
***50** enable/disable tel #'s
*Individual access privilages
*Directed/general & reverse page
*Full or Half duplex (level cont.)
*Security mode/ TT readback on/off
*Store MCI/Sprint tel. #'s
*Reverse Patch active all modes
*Call waiting/quick dial & reset

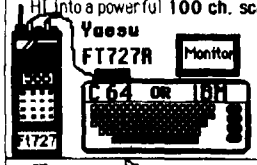
V.H.F. REMOTE #2
*Dual VFO's/ Rev/Split/COR detect
*Set Scan Inc. & offset/var. resume

Super Comshack CS64S $349.95 + $4.00 ship USA; incl. computer interface, disk, cables & manual (simplex version inc. on request)

SYSTEM OPTIONS
*External Relay Control 3 DPDT relays + 5 open collector outputs..**CS-8$79.95**
*EPROM Auto boot Cartridge customized with your system .....**CART$99.95**
*Beam control, speaks bearing and rotates beam ;1 degree incre. **HM1 $49.95**
*Manual (Refunded).....**MN1 $15.00**
*Row & col. freq. control..**RAP $149.95**
*C64 D.C. Switcher P.S. **DCPS $119.95**

MINI (BEAR CAT) COMPUTER CONTROL FT-727R

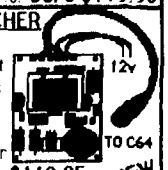
Programs and Scans 100 ch. in Ham/General coverage. Converts HT into a powerful **100 ch. scanner** & programs all for field use!



*Digital "S" meter; stops scan from S(1-9); Auto resume
*Loads & programs all FT-727R parameters in less that 15 secs.
*Includes hardware & disk for C64 or IBM PC

MODEL 727S $39.95

12v C64 SWITCHER
*Draws 1.1A @12v.
*70khz 75% efficient
*Outputs 5v @2 amps and 9 vac 60Hz
*Crystal time base
*Plugs into C64 power



MODEL DCPS.....$119.95 NEW

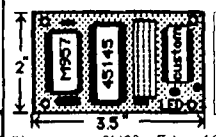


Touchtone to RS-232 (300 baud interface)

Program your computer in basic to decode multidigit "strings", sound alarms, observe codes, includes basic program for C64 VIC20/C128; **works on all computers!**

MODEL DAP $89.95

Touchtone 4 Digit Decoder
& on/off latch with all 16 Digits



Expandable Repeater on/off control

*Low power CMOS +5 to +12 Volts
**User programable 50,000; 4 digit codes*
*Send code once to turn on, again to turn off
*Momentary & Latch output drives relay
*Wrong digit reset; no falsing; 2 to 4 digits
*Mute speaker audio until call is received
*LED displays latch state; Optional 4 digit extra custom latch,(7225) IC's $6.95 ea.
***Model TSD $59.95**

"Audio Blaster" IC-02/04 AT;2AT;U16;FT209;FT727R



Module **installs inside the radio** in 15 Min. Boost audio to **1 watt!** Low standby drain/Corrects low audio/1000's of happy users. Minature audio amplifier --> LM-381 Used by Police, fire, Emergency, when it needs to be **HEARD!**

WoW! thats **loud** now!!! You can hear everything!

FOR ALL H.T.'S

MODEL ABI-$19.95

ENGINEERING CONSULTING ** 583 CANDLEWOOD ST. BREA, CA. 92621**
MASTERCARD ** VISA ** CHECK M.O. ** CA. RES. ADD 6% TEL: 714-671-2009**

ALL BAND TRAP "SLOPER" ANTENNAS!



FULL COVERAGE! ALL BANDS! AUTOMATIC SELECTION with PROVEN Weatherproof sealed Traps - 10 Ga. Copperweld Wire! GROUND MOUNT SLOPERS - No Radials needed! Ground to rod or house water faucet! Connect Top to Trees, Buildings, Poles, etc at ANY angle from Straightup to 90 degrees for excellent "SLOPER" DX Antenna Gain or bend it anywhere you need to! 2000 Watt PEP input, max. Permanent or portable Use. Installs in 10 minutes. SMALL - NEAT - ALMOST INVISABLE - No one will know you have a Hi-Power DX Antenna. Ideal For COND'Os APARTMENTS- RESTRICTED AREAS - Pre-tuned for 2-1 or less SWR over ALL bands (except 80-160-300Khz). No adjustments needed - EVER. COMPLETELY ASSEMBLED, with 50 ft RG-58U Coax feedline and PL259 connector-. Built in lighting arrestor - ready to hookup! FULL INSTRUCTIONS!

No. 1080S - 80-40-20-15-10 — 1 trap 49 ft. — $59.95
No. 1040S — 40-20-15-10 — 1 trap 26 ft. — $59.95
No. 1020S — 20-15-10 — 1 trap 13 ft. — $57.95
No. 1016S-160-80-40-20-15-10-2 traps 83 ft. — $89.95

SEND FULL PRICE FOR PP DEL IN USA (Canada is $5.00 extra for postage etc) or order using VISA, MASCARD - AMEX EXP. Give Number Ex Date. Ph 1-308-236-5333 weekdays. We ship in 2-3 days (Per Clks 14 days) Guaranteed 1 yr - 10 day money back trial.

WESTERN ELECTRONICS
Dept. AH Kearney, Nebraska 68847

137

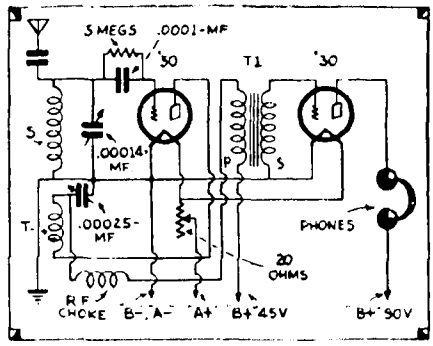
AMATEUR RADIO MAIL LISTS
Self-stick 1x3 labels

*** NEWLY LICENCED HAMS ***
*** ALL NEW UPGRADES ***
*** UPDATED EACH WEEK ***

Total List = 462,728 (ZIP sorted)
Price is 2.5 cents each (4-up Cheshire)

BUCKMASTER PUBLISHING
Mineral, Virginia 23117
703:894-5777

138



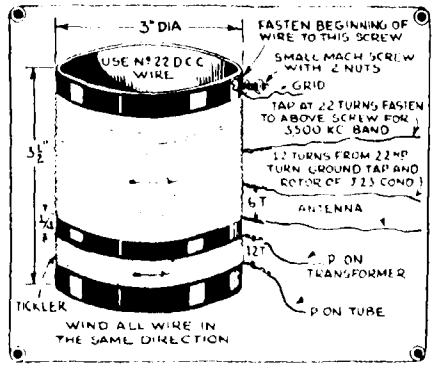


fig. 5. A real shortwave receiver for pennies that actually works. Thousands of would-be hams built this simple set from the pages of "Short Wave Craft" during the "thirties" and were thrilled with world-wide reception.

transmitters allowed groups of enthusiasts to talk all over town and once in a while — even out of state!

Then, shortly after 5:00, the "big boys" started coming on the air, after getting home from work. How could a little 20-watt modulated oscillator compete with a high-power, 50-watt crystal-controlled rig? It couldn't, and the high-school gang regretfully went QRT until the next day.

As the months went by, the high-school afternoon gang slowly disappeared. Some went to college, others got jobs. Most of them upgraded their equipment and the little oscillators were forgotten.

So was *Short Wave Craft* magazine. The breathless, wide-eyed approach to shortwave radio was out of fashion. Build-it-yourself projects still appeared in the magazine, but they were aimed

at more technically minded readers. An increasing portion of the magazine was devoted to television. More and more young Amateurs turned to *QST*, which suited their moods better. Even so, the "greatest little radio magazine in the world" lasted until after World War II, when it was reborn as *Radio Electronics*, which endures today as one of the many Gernsback Publications.

TVI revisited

Now that 10 meters is coming back to life, the problem of TVI is becoming more prevalent. Since the last big period of 10-meter activity (around 1978), television has undergone changes. More and more receivers are either on cable systems or, if they're not, employ 75-ohm coax lead-in instead of the popular 300-ohm ribbon line.

TVI (high-pass) filters are available for 75-ohm line, but they don't seem to do the job. I've given some filters to my neighbors, but they report very little improvement when I'm on 10 meters and they're watching channel 2. I crosshatch the screen with lines regardless of whether the filter is installed in the line or not.

The problem seems to be that the 75-ohm line acts as an antenna for my signals, and the TV antenna itself has little to do with it. If the coax line can be broken at the set, from a TVI point of view, the interference should disappear.

My friend "Bip", W6BIP, who's an expert when it comes to TVI problems and solutions, tipped me off on how to cure this worrisome interference. His solution, which works fine for me, is to use two 4:1 TV balun transformers back-to-back with a 300-ohm TVI filter connected between them (**fig. 7**). The balanced filter breaks both line conductors and the baluns prevent line unbalance caused by inserting the filter.

Bip cautioned me that the little TV baluns (which are nothing more than a few fine windings on a ferrite bead) have some loss, and if this trick is tried in an area of low TV signal strengths, it might put too much "snow" on the picture. The solution, then, is to install a broadband amplifier after the filter and before the TV set.

Bip also pointed out that it's good insurance to wrap the power cord to the TV around a high-permeability ferrite core just to prevent the possibility of your signal sneaking in through "the back door" of the TV set.

I'd be interested in hearing from readers who have solved tough interference problems. Your solution may help others who are in trouble. Write to me at Box 7508, Menlo Park, California 94025, with your ideas.

ham radio

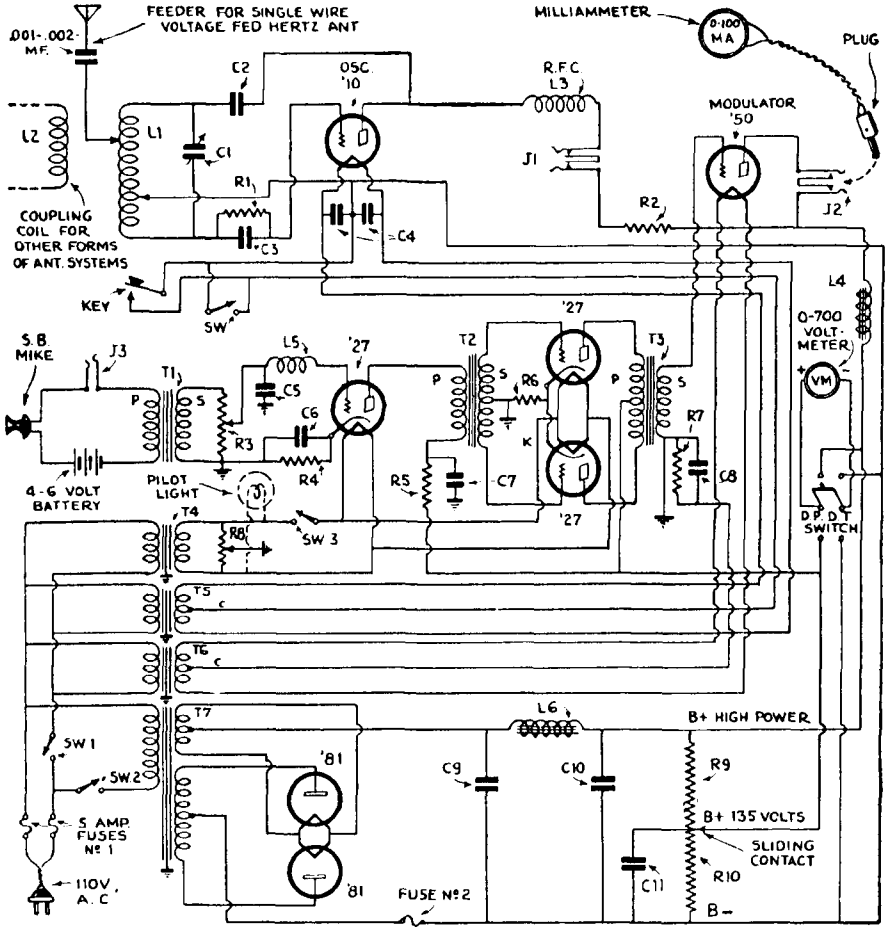
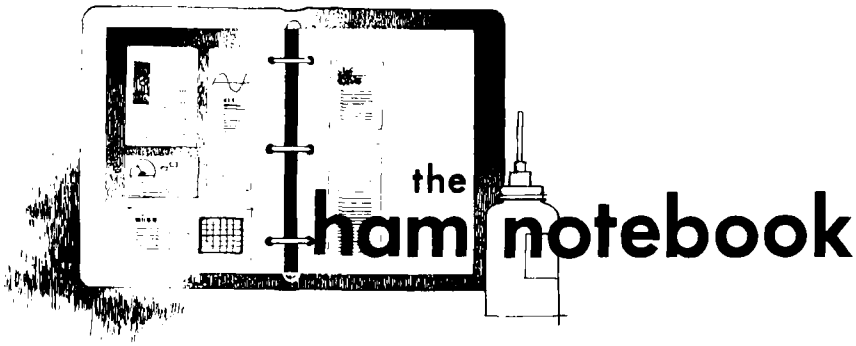


fig. 6. This modulated oscillator provided a 15 watt carrier. If properly built, the stability was passable and audio quality was quite good, considering a telephone microphone was used. The whole rig was breadboard construction on three shelves. Hams who could not afford a 10 transmitting tube, dropped the voltage and used a 245 or a 226, depending upon the state of their pocketbook.



fig. 7. Balanced filter breaks both conductors of 75 ohm coax for improved TVI reduction.



rebuild your C-64 keyboard with C-16 parts

Some heavily used Commodore 64 computers develop the dreaded "keyboard stutter" and certain letters fail to print as their keys are depressed. Disassembling the keyboard unit and cleaning the printed circuit board provides only a temporary solution as the cause of the problem is a loss of elasticity in a small plastic part in the keys.

Radio Shack stores, Jameco, and All Electronics Corporation sell a surplus keyboard unit for the Commodore 16 computer. While not electrically compatible with the C-64 keyboard, the moving mechanical parts are identical and can be used to rebuild it. The job takes a couple of hours and requires more patience than technical expertise. Use the procedure below to minimize parts fall-out.

Start by removing all the keytops from the C-16 board. They can be snapped off their pins by prying under one side with a flat screwdriver while pressing against the opposite side with your thumb. There is a small coil spring under each keytop. Set the keyboard aside.

Open the C-64 by removing the three screws underneath and gently prying the unit apart at the front. Unplug the top unit from the main board and set the bottom unit aside. Remove the keyboard from the top part of the computer by taking out the large Phillips head screws. Set the top part of the case aside. Take the keytops from the C-64 keyboard and install them on the C-16 board. Make sure that a spring is in place under each keytop and each key is snapped in place on its pin.

Unsolder the two wires attached to the small gray plastic square on both keyboards. Detach the printed circuit board from the C-16 keyboard by removing the 30 or so tiny Phillips screws and gently prying it out. Discard this board and the attached wires. Take the printed board from the C-64 keyboard and install on the C-16 board, making sure the two wires are soldered in place. Discard the remains of the old C-64 keyboard.

Install the rebuilt keyboard in the C-64 and reassemble the computer. Enjoy!

Don Norman, AF8B

curing *FT-101ZD* key clicks

The FT-101ZD transceivers are indeed excellent. But when we used a couple of them in our multi-multi cw contest station, we received several reports of heavy key clicks from frequency neighbors.

After the contest, I spent a number of hours trying various modifications to the solid-state keying unit located in Rectifier B, with two burned-out transistors and only marginal improvement. Finally I decided that the time constants in the 12BY7A driver and the 6146s final grid bias circuits had to be changed.

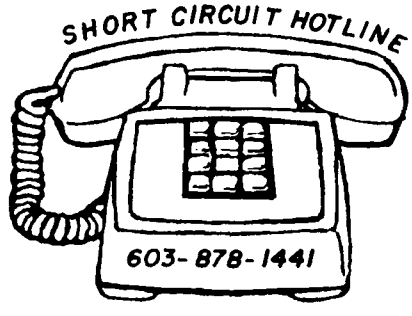
This was a quick and easy solution. Installing two capacitors — a 0.47-to-1.0 μF capacitor from the 12BY7A bias terminal to ground and a 1.0-to-3.0 μF capacitor from the 6146 bias terminal to ground — eliminated all clicks. Both of these capacitors should be rated at 200 volts dc or more, and the *positive* ends of the capacitors should go to ground. (The lower values are for the 80 wpm types. At 30 wpm, the higher values are fine, although either set will eliminate the problem.)

The modification is simple. Remove the top and bottom covers of the FT-101ZD and place the set on its right side. The Rectifier B Board is located near the back. Terminals are clearly identified: the ground terminal is towards the rear of the set on the second row of terminals; the 12BY7A bias terminal is the third terminal, and the 6146 bias terminal is the fourth terminal in that row.

I later decided that a slightly better solution would be to connect the negative end of the capacitor for the 12BY7A to the junction of R12 and R17, and the negative end of the capacitor for the 6146 to the junction of R13 and the center lead of VR01. I tried this with clip leads and it worked, but a permanent installation would have been more difficult. The keying is clickless now, so I left it alone.

(Others have tried this modification on the FT-901, FT-902, and FT-102 and found it to be effective.)

R.H. Mitchell, N5RM



PRACTICALLY SPEAKING ... Joe Carr K4IPV

noise, signals, and amplifiers

Gain, bandwidth, and passband shape are important amplifier characteristics on any band, but circuit noise is the first consideration with VHF, UHF, and microwave amplifiers. In the spectrum below VHF, manmade and natural atmospheric noise sources are so dominant that most receiver noises are masked. But at VHF and above, receiver and amplifier noise determines system performance. In this month's column, we look at the various sources of noise and why low-noise amplifiers (LNA) are used only in the first stage or two of a receiver or cascade chain.

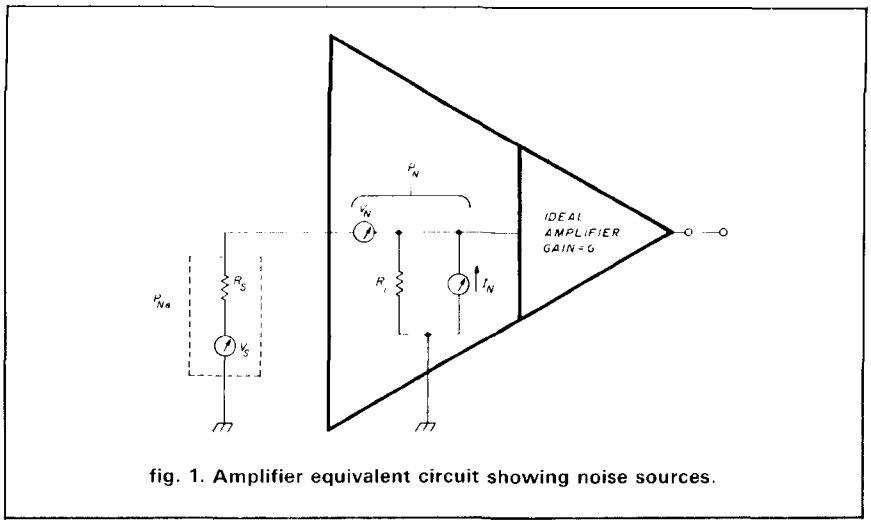


fig. 1. Amplifier equivalent circuit showing noise sources.

At any temperature above Absolute Zero (0°K or −273 °C), electrons in any material are in constant random motion and there is no detectable current in any single direction. Electron drift in any single direction is canceled over short time periods by equal drift in the opposite direction. There is, however, a continuous series of random current pulses generated in the material. Those pulses are seen by the outside world as a noise signal. This signal is called: thermal agitation noise, thermal noise, or Johnson noise.

It's important to understand what is meant by *noise* in this context. In a communications system the designer may regard all unwanted signals as noise, including manmade electrical spark signals, adjacent channel communications signals, and Johnson noise. In other cases, the harmonic content generated in a linear signal by a nonlinear network could be regarded as noise. But in the context of VHF/UHF amplifiers and receivers, noise refers to thermal agitation (Johnson) noise.

Amplifiers and other linear networks are frequently evaluated using the same methods, even though the two classes appear radically different. In the generic sense, a passive network is merely an amplifier with negative gain or a complex transfer function. We will consider only amplifiers here, but keep in mind that linear (passive) networks follow the same rules.

Amplifiers and receiver front ends are evaluated on the basis of signal-to-noise ratio (S/N or SNR). Designers try to enhance the SNR as much as possible. Ultimately, the minimum signal detectable at the output of an amplifier or receiver appears above the noise level. Therefore, the lower the system noise, the smaller the minimum detectable signal (MDS).

Noise resulting from thermal agitation of electrons is measured in terms of noise power (P_n), and carries the units of power (watts or its subunits). Noise power is found from:

$$P_n = KTB \qquad (1)$$

where:
P_n is the noise power in watts
K is Boltzmann's constant (1.38×10^{-23} J/°K)
B is the bandwidth in Hertz

Notice in **eqn. 1** that there is no center frequency term, only a bandwidth. True thermal noise is gaussian (or near-gaussian) in nature, so frequency content, phase, and amplitudes are equally distributed across the entire spectrum. In bandwidth limited systems, such as a practical amplifier or network, the total noise power is related only to temperature and bandwidth. A 20-kHz bandwidth centered on 440 MHz should, in theory, produce the same thermal noise level as a 20-kHz bandwidth centered on 144 MHz or some other frequency.

Noise sources can be categorized as either internal or external. Thermal currents in the semiconductor material resistances produce internal noise. Consider the noise component contributed by the amplifier. If noise, or S/N ratio, is measured at both input and output of an amplifier, the output noise is greater. The internally generated noise is the difference between output and input noise levels.

External noise is produced by the signal source(s), so it is often called source noise. This noise signal is caused by thermal agitation currents

in the signal source, and even a simple zero-signal input termination resistance has some amount of thermal agitation noise.

Both types of noise generator are shown schematically in **fig. 1**. Here we model an amplifier as an ideal "noiseless" amplifier with a gain of G, and a noise generator at the input. This generator produces a noise power signal at the input of the ideal amplifier. Although noise is generated throughout the amplifying device, it is common practice to consider all noise generators as a single input-referred source. This is shown as voltage V_N and current I_N.

noise factor, figure, and temperature

System or network noise can be defined in three ways: noise factor (F), noise figure (NF) and equivalent noise temperature (T_e). These properties are definable as a ratio, decibel, or temperature, respectively.

Noise Factor (F). The noise factor is the ratio of output noise power (P_{no}) to input noise power (P_{ni}):

$$F = \left.\frac{P_{no}}{P_{ni}}\right| \quad T = 290\ ^\circ K \qquad (2)$$

To make comparisons easier, the noise factor is always measured at the standard temperature (T_0) 290 °K (approximately room temperature).

Input noise power P_{ni} is the product of the source noise at standard temperature (T_0) and the amplifier gain:

$$P_{ni} = GKBT_0 \qquad (3)$$

Noise factor F can also be defined in terms of output and input S/N ratio:

$$F = \frac{SNR_{in}}{SNR_{out}} \qquad (4)$$

which is also:

$$F = \frac{P_{no}}{KT_0BG} \qquad (5)$$

where:
SNR_{in} is the input signal to noise ratio
SNR_{out} is the output signal to noise ratio
P_{no} is the output noise power
K is Boltzmann's constant (1.38×10^{-23} J/°K)
T_0 is 290 degrees Kelvin
B is the network bandwidth in hertz
G is the amplifier gain

The noise factor can be evaluated in a model that considers the amplifier ideal, and therefore only amplifies through gain G the noise produced by the *input* noise source:

$$F = \frac{KT_0BG + \Delta N}{KT_0BG} \qquad (6A)$$

or,

$$F = \frac{\Delta N}{KT_0BG} \qquad (6B)$$

where:
ΔN is the noise added by the network or amplifier
All other terms are as defined above.

Noise Figure (NF). The noise figure is a frequently used measure of an amplifier's *goodness*, or its departure from *idealness*. Thus it is a figure of merit. The noise figure is the noise factor converted to decibel notation:

$$NF = 10 \text{ LOG } F \qquad (7)$$

where:
NF is the noise figure in decibels (dB)
F is the noise factor
LOG refers to the system of base 10 logarithms

Example 1

Calculate the noise figure in dB of an amplifier that has a noise factor of 5.27.

NF = 10 LOG F dB = 10 • LOG 5.27 dB = 7.2 dB

Noise Temperature (T_e). The noise *temperature* specifies noise in terms of an equivalent temperature. **Equation 1** shows that noise power is directly proportional to temperature in degrees Kelvin, and that noise power reduces to zero at Absolute Zero (0 °K).

The equivalent noise temperature T_e is not the physical temperature of the amplifier, but a theoretical construct that is an equivalent temperature producing that amount of noise power. The noise *temperature* is related to the noise factor by:

$$T_e = (F - 1)\ T_0 \qquad (8)$$

and to noise figure by:

$$T_e = \left[ANTILOG\left(\frac{NF}{10} - 1\right)\right] \cdot T_0 \qquad (9)$$

Using noise temperature T_e, we can define noise factor and noise figure in terms of noise temperatures:

$$F = \frac{T_e}{T_0} + 1 \qquad (10)$$

and,

$$NF = 10\ LOG\left(\frac{T_e}{T_0} + 1\right) \qquad (11)$$

Curves of noise figure and noise temperature are plotted in **fig. 2**.

Total noise in any amplifier or network is the sum of internally and externally generated noise. In terms of noise temperature:

$$P_n(\text{total}) = GKB(T_0 + T_e) \qquad (12)$$

where:
P_n (total) is the total noise power
All other terms are as previously defined.

Although the equations tend to show absolute equivalence and convertibility between F, NF, and T_e, there can be confusion about proper practices for optimizing an amplifier as regards to matching the input and source resistances. There is an optimum source resistance for minimizing input noise power and for maximum power transfer to the amplifier (source resistance equals amplifier input resistance). Unfortunately, the two optimum resistances are rarely the same. While impedance matching is useful, some common tactics are not.

Some designers modify the source resistance by adding a series or shunt resistance to the circuit. This brings the total source resistance seen by the amplifier to the optimum value for noise figure reduction. In the case cited, the noise contributed by the added resistor (KTBR) increases input noise to a point that dominates and masks amplifier internal noise. Unfortunately, this tactic while appearing to

improve F, actually does not affect it, but deteriorates output signal to noise ratio (SNR_{out}).

noise in cascaded amplifiers

Since noise is considered a valid signal, the last stage in a cascaded amplifier chain receives an amplified version of the original input signal and prior stage noise contributions (**fig. 3**). Each stage in the chain amplifies signals and noise from previous stages, and contributes some noise of its own. The overall noise factor for a cascaded amplifier chain can be calculated using Friis' noise equation:

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \cdots + \frac{F_n - 1}{G_1 G_2 \cdots G_{n-1}} \quad (13)$$

or, in terms of noise temperature

$$T_e = T_1 + \frac{T_2 - 1}{G_1} + \frac{T_3 - 1}{G_1 G_2} + \cdots + \frac{T_n - 1}{G_1 G_2 \cdots G_{n-1}} \quad (14)$$

where:
F is the overall noise factor of N stages in cascade
T_e is the overall noise temperature of N stages in cascade
F_1 is the noise factor of stage 1
F_2 is the noise factor of stage 2
F_n is the noise factor of the nth stage
T_1 is the noise temperature of stage 1
T_2 is the noise temperature of stage 2
T_{n-1} is the noise temperature of the (n - 1)st stage
G_1 is the gain of stage 1
G_2 is the gain of stage 2
G_{n-1} is the gain of stage (n - 1).

As you can see from **eqns. 13** and **14**, the noise factor or noise temperature of the entire cascade chain is dominated by the noise contribution of the first stage or two. Typically, high sensitivity microwave amplifiers use a low-noise amplifier (LNA) stage for only the first stage or two in the cascade chain. For example, a microwave satellite ground station receiver will have an LNA at the antenna feedpoint,

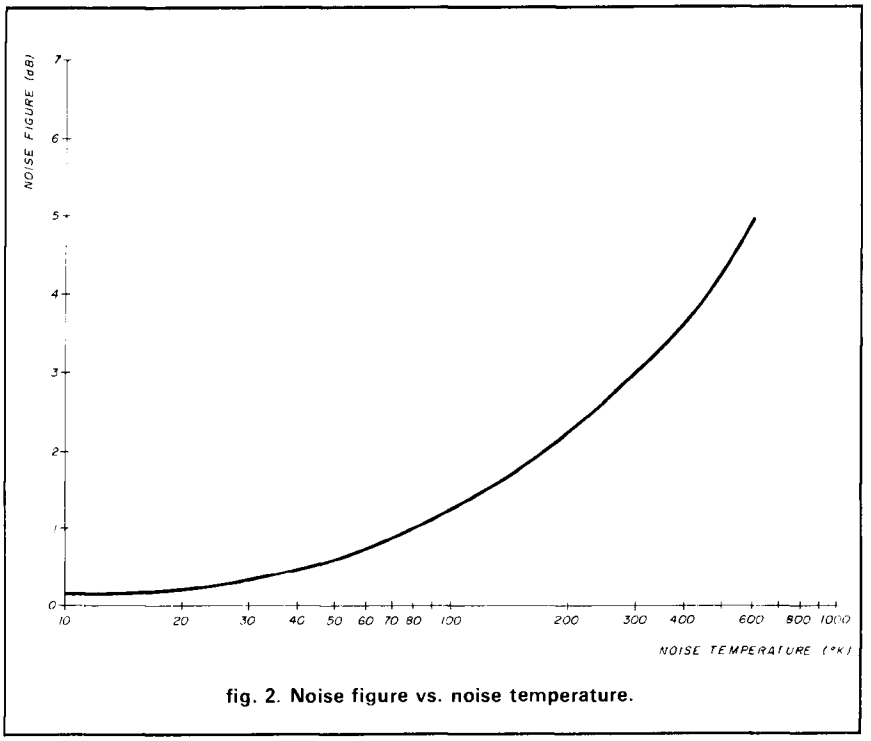


fig. 2. Noise figure vs. noise temperature.

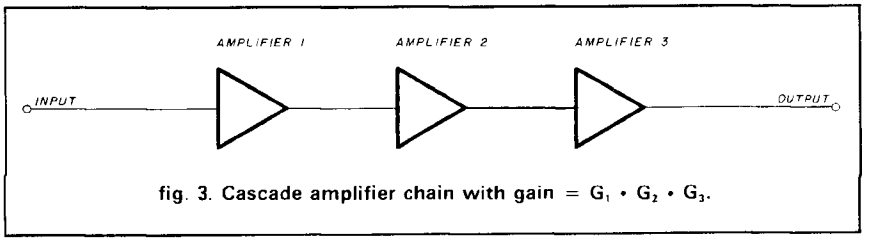


fig. 3. Cascade amplifier chain with gain = $G_1 \cdot G_2 \cdot G_3$.

and then non-LNA stages following the transmission line.

example 2

A three-stage amplifier (**fig. 3**) has the following gains: $G_1 = 10$, $G_2 = 10$, and $G_3 = 25$. The stages also have these noise factors: $F_1 = 1.4$, $F_2 = 2$ and $F_3 = 3.6$. Calculate a) the gain of the cascade chain in decibels, b) the noise factor, and c) the noise figure. Solution:

a) $G = G_1 G_2 G_3 = 10 \cdot 10 \cdot 25 = 2500$
G (dB) = 10 LOG 2500 = 34 dB

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2}$$

$$F = (1.4) + \frac{(2-1)}{10} + \frac{(3.6-1)}{10 \times 10} \quad (15)$$

$$F = 1.4 + \frac{1}{10} + \frac{2.6}{100}$$

$$F = 1.4 + 0.1 + 0.026 = 1.53$$

c) NF = 10 LOG F = 10 log 1.53 = 1.9 dB

Note in the above example, that the overall noise factor (1.53) is only slightly worse than the noise factor of the input amplifier (1.4), and is better than the noise factors of the following stages (2 and 3.6, respectively). Clearly, the overall noise factor is set by the input stage. This is why we use low-noise amplifiers in the frontends of VHF, UHF, and microwave receivers, while amplifiers later in the cascade chain are lesser quality circuits with respect to noise.

Joe Carr can be reached at POB 1099, Falls Church, Virginia 22041.

ham radio

VHF/UHF WORLD

Joe Reisert W1JR

loose ends

I must apologize for missing the January *ham radio* issue. No, I wasn't in outer Mongolia as might have been reported!

Every so often it's good to sit back and take stock of where you are and where you're heading. This column is no exception. It's hard to believe that this is the start of the fifth year for "VHF/UHF World". Your suggestions for topics are always appreciated.

This month's column will tie up some loose ends and answer some of your letters. I appreciate all of them. I'll also update the North American VHF/UHF records.

upcoming events

Many readers send information on upcoming events. Please remember to write three or four months before an event so that I can list it.

There has been interest expressed in the meteor shower peaks. The lists came from information given in my talk at the Central States VHF Conference in Sioux Falls, South Dakota in July 1981. Later, Russ Wicker, W4WD, generated a computer program that automatically calculates the peaks. My son, Jim, AD1C, modified this program for personal computers. See reference 1.

This method of prediction relies on data and information accumulated from earlier showers. The information isn't always accurate for some of the meteor showers. If the shower radiant (the point in the sky from which the meteors seem to be emanating) is not optimum for the desired transmission direction, the peak time may be poor or nonexistent.

Reference 2 shows how to tie the shower peak and the radiant together. This information, available for personal computers, takes much of the guesswork out of meteor scatter communications. It highlights the optimum dates, a help with the shorter duration showers especially in leap years.

references

I'm told that few Amateur Radio writers cite as many references as I do. I try to make each month's column stand on its own. Sufficient material is included in each column and references are provided for those who want to dig further. While some of the references are either unavailable or difficult to obtain, I do have all of them on file.

I try to arrange the material in this column in building-block fashion so I can cite my columns in back issues. They can be purchased from *ham radio* Bookstore ($5 each postpaid, 3 for $13.95) and I often see back issues at Amateur flea markets.

state of the art

There has been considerable progress in the VHF/UHF field in the last few years. In January 1984, SSB on 23 cm (1296 MHz) was uncommon in many parts of the United States. Now commercial 23-cm CW/SSB transverters and stand-alone multimode transceivers can be purchased for all Amateur bands below 13 cm (2300 MHz). Only transverters are available for the new 33-cm (902-928 MHz) band. Commercial Amateur CW/SSB transverters now run as high as 3 cm (10 GHz).

Amateurs now use SSB as high as 48 GHz.[3] EME operation above 13 cm was an untouched field through 1986; this has changed with Amateur EME contacts now reported through 6 cm (5760 MHz) and possibly 3 cm before this column goes to print.

The VHF/UHF/Microwave field is expanding with new technology such as MMICs (monolithic microwave ICs),[4] GaAs (Gallium Arsenide) FETs, and HEMTs (High Electron Mobility Transistors) in common use.[5] I will try to keep you informed about developments.

new VHF/UHF/Microwave records

Until 1985, VHF/UHF/Microwave DX records were usually shown on the basis of worldwide accomplishments with little regard to the propagation mode. This tended to discourage record challenges since many of them took place in areas where special

table 1. North American VHF and above claimed DX records. Revised October 29, 1987.

N. American VHF and Above Claimed DX Records (notes 1 & 2) Revised 29 Oct. 1987

Frequency	Record Holders	Date	Mode DX	Miles	(km)
50 MHz	Note 3				
EME	K6MYC (CM97EB)-K8MMM (EN91BK)	84-07-24	CW	2127	(3422)
144 MHz					
Aurora	KA1ZE (FN31TU)-WB0DRL (EM18CT)	86-02-08	CW	1347	(2167)
Ducting	KH6GRU (BL01XH)-WA6JRA (DM13BT)	73-07-29	CW	2586	(4161)
EME	VE1UT (FN63XV)-VK5MC (QF02EJ)	84-04-07	CW	10,985	(17676)
Spor. E	KD4WF (EN92LK)-NW70/7 (DM25GV)	87-06-14	SSB	1980	(3186)
FAI	W5HUQ/4 (EM90GC)-W5UN (DM82WA)	83-07-25	CW	1228	(1976)
MS	K5UR (EM35WA)-KP4EKG (FK68VG)	85-12-13	SSB	1960	(3153)
TE	KP4EOR (FK78AJ)-LU5DJZ (GF11LU)	78-02-12	SSB	3933	(6328)
Tropo	K1RJH (FN31XH)-K5WXZ (EM12QW)	68-10-08	CW	1468	(2362)
220 MHz					
Aurora	W3IY/4 (FM19HA)-WB5LUA (EM13QC)	87 07 14	CW	1145	(1842)
Ducting	KH6UK (BL11AQ)-W6NLZ (DM03TS)	59-06-22	CW	2539	(4086)
Spor. E	K5UGM (EM12MS)-W5HUQ/4 (EM90GC)	87-06-14	CW/SSB	932	(1499)
EME	K1WHS (FM43MK)-KH6BFZ (BL11CJ)	83-11-17	CW	5058	(8139)
MS	K1WHS (FM43MK)-K0ALL (EN16NW)	85-08-12	SSB	1279	(2057)
TE	KP4EOR (FK78AJ)-LU7DJZ (GF05RJ)	83 03-09	CW/SSB	3670	(5906)
Tropo	VE3EMS (EN86QJ)-WB5LUA (EM13QC)	82-09-28	SSB	1181	(1901)
432 MHz					
Aurora	W3IP (FM19PD)-WB5LUA (EM13QC)	86-02-08	CW	1182	(1901)
Ducting	KD6R (DM13NI)-KH61AA/P (BK29GO)	80-07-28	CW	2550	(4103)
EME	K2UYH (FN20QG)-VK6ZT (QF78VB)	83-01-29	CW	11,567	(18612)
MS	W2AZL (FN20VI)-W0LFR (FN35IA)	72-08-12	CW	1019	(1640)
Tropo	WB3CZG (FN21AX)-WA5VJB (EM12LQ)	86-11-29	SSB	1318	(2121)
903 MHz					
Tropo	W2PGC (FN02OR)-K3SIW/9 (EN52WA)	86-12-24	SSB	478	(769)
1296 MHz					
Ducting	KH6HME (BK29GO)-WB6NMT (DM12KU)	86-08-13	SSB	2528	(4068)
EME	K2UYH (FN20QG)-VK5MC (QF02EJ)	81-12-06	CW	10,562	(16995)
Tropo	WB3CZG (FN21AX)-KD5RO (EM13PA)	86-11-29	CW	1287	(2070)
2304 MHz					
EME	PA0SSB (JO11WI)-W6YFK (CM87WI)	81-04-05	CW	5492	(8837)
Tropo	KD5RO (EM13PA)-W8YIO (EN82BE)	86-11-29	CW	940	(1513)
3456 MHz					
Tropo	WA5TNY/5 (EM11AU)-WB5LUA/5 (EM24UQ)	86-10-19	CW	288	(464)
EME	W7CNK/5 (EM15FI) K0KE/0 (DM79NO)	87-04-12	CW	498	(802)
5760 MHz					
Tropo	K5PJR (EM26OP)-W5UGO/0 (EN00PH)	87-07-04	CW	332	(535)
EME	WA5TNY (EM12KV)-W7CNK/5 (EM15FI)	87 04-24	CW	174	(279)
10.368 GHz					
Tropo	N6GN/6 (CM89PX)-W6SFH/6 (DM04MS)	87-07-19	CW	414	(666)
24.192 GHz					
LOS	WA3RMX/7 (CN93IQ)-WB7UNU/7 (CN95DH)	86-08-23	SSB	116	(186)
47.040 GHz					
LOS	WA3RMX/K7RUN (CN85PL)-WB7UNU/W7TYR/W7ADV (CN85NH)	87-03-07	SSB	5.42	(8.72)
76-149 GHz	None reported				
474 THz					
LOS	K6MEP (DM04IO)-WA6EJO (DM04KT)	79 06-09	LASER	15	(24)

Note 1. The records are listed alphabetically by mode. Ducting is suspected where the path is mostly over water. No efforts are made to separate out ducting on overland paths so they're grouped under tropo.

Note 2. The information within the brackets ( ) is the grid square locator.

Note 3. 6-meters records, excepting EME, were left off since the primary mode is often hard to distinguish. Also long-path QSOs have been reported during solar cycles 19 and 21 which exceed 12433 miles (20004 km).

propagation phenomenon occurs. In my July 1985 column,[6] I started listing VHF/UHF/Microwave records for North America by band and propagation mode when known. Judging from the response, this type of record listing has become very popular.

Since the last listing of North American DX records was published[3], many have been broken and some new modes were added. I have updated the DX records based on the latest information (**table 1**).

New record challenges must be carefully documented and compared with existing records. The distance is very important since records on these frequencies are often extended by as little as one mile. Therefore, precise locations (latitude and longitude) are essential. Send me an SASE if you want record forms.

worldwide locator system

The Maidenhead system, in its six-digit form, is accurate to within a few miles. Some contests now require grid squares or locators on QSLs; reference 3 shows how to determine yours. It's important that all VHFers know their latitude and longitude to at least 3 seconds accuracy.

Computer programs can now determine the grid square.[7] If you'd like, send me your latitude and longitude in degrees, minutes, and seconds with an SASE and I will figure your six-digit grid square.

I have upgraded the list of the most well-known mountain tops in the United States[8] to include the six-digit locators; a revised list is shown in **table 2**. If you have information, please send it for inclusion in a later column.

There is some controversy about the equity of the new ARRL VUCC (VHF/UHF Century Club) awards. Before the grid square awards, the coveted prize for VHFers was the Worked All States award. Depending on the frequency, this tended to favor either the Northeastern or Midwestern states.

The grid squares were considered a partial equalizer. Some say this, too, is unfair because grid squares are wider in the southern United States than near the Canadian border. A distance calculation program shows this to be true; the width of a grid square is about 120 miles at 30 degrees and just below 100 miles at 45 degrees latitude.[7]

It seems difficult to develop a truly fair system because of all the factors. Tropo propagation is much more prevalent in the lower latitudes, especially from Florida to Texas, and where the land is flat. Mountains, on the other hand, can either impede or aid in line-of-sight communications. Almost half of the grid squares in coastal regions are under water.

I'll be willing to bet that there is more activity, interest, and equity generated by grid squares than working all states. VUCC awards are possible on any band but how does one obtain a Worked All States on 2 meters or above without EME?

table 2. This table shows some of the most famous mountain top locations that have been popularized by VHF/UHF/Microwave and Millimeter-wave'rs to set DX and contest records.

Mountain	Location (approximate)	Grid Square
Eastern USA		
Cadillac Mountain	Bar Harbor, Maine	FN54VI
Mount Washington	Glen, New Hampshire	FN44IG
Pack Monadnock	Peterborough, New Hampshire	FN42BU
Mount Equinox	Manchester, Vermont	FN33JC
Mount Mansfield	Burlington, Vermont	FN34ON
Mount Greylock	North Adams, Massachusetts	FN32JP
High Point	Port Jervis, New Jersey	FN21EH
Watchusett Mountain	Princeton, Massachusetts	FN42BL
Mount Mitchell	Asheville, North Carolina	EM85US
Mount Toxaway	Oakland, North Carolina	EM85MD
Spruce Knob	Simoda, West Virginia	FM08FQ
Western USA		
Pikes Peak	Colorado Springs, Colorado	DM78BA
Mount Rose	Reno, Nevada	DM09AQ
Mount Potasi	Las Vegas, Nevada	DM25GV
Mount Diablo	Walnut Creek, California	CM97AU
Mount Hamilton	San Jose, California	CM97EI
Mount Frazier	Frazier Park, California	DM04MS
Mount Pinos	Frazier Park, California	DM04KT
Mount Palomar	Julian, California	DM13OJ
Mount Ashland	Ashland, Oregon	CN82PB

new leadership

Another new trend, the formation of clubs specializing in VHF/UHF and microwaves, is rapidly developing. Some sponsor conferences; others have monthly meetings and publish newsletters. Clubs can unite Amateurs for group projects and purchases.

My list of clubs involved in VHF and above is probably incomplete. Please help by supplying information so we can publish a list and create interest in the higher frequency bands.

antennas

I get lots of questions on antenna selection. There is no firm answer on which is the perfect antenna. Some have high gain on a long boom while others are aimed at the cleanest possible pattern on a shorter boom. Some Amateurs prefer to use single long Yagis while others like to stack shorter or longer boom antennas. Each Amateur has specific needs for his or her setup.

The cost of antennas and/or antenna improvements are usually well below the cost of improving your receiver or transmitter power (if you're not already at the legal limit). VHF/UHF

antennas are also more manageable than hf antennas.

Last May I mentioned the availability of the MININEC 3 antenna modeling program. The program is now only available through NTIS as described in **Short Circuits** in July 1987.[3] In the May column[9] I also described optimized 6 and 2-meter Yagis that are easy to duplicate, have clean patterns and high gain per unit boomlength. The materials used, and the way I matched the driven element of the 2-meter Yagi, made the driven element longer than the reflector. I was surprised that so many people duplicated it exactly as shown, since most Amateurs have their own ideas about materials. The length of the driven element in **fig. 2** is correct as shown.

Then there are the insulators and keepers used on the insulated boom 2-meter Yagi[9] and the 70-cm (432 MHz) Yagi.[10]The ones recommended use either Lexan™ or polystyrene with black carbon impregnated (for UV protection) but never nylon. The outer portion of the insulator is approximately 0.425 inches in diameter with a thickness of 0.165 inches, and the inner diameter is 0.305 inches with a thickness of 0.150 inches. The hole in the center is 0.190 inches to accomodate a 3/16 inch diameter aluminum rod. Suitable insulators are now available from Tom Rutland, K3IPW*. Tom will also supply kits or parts for the 31-element 70-cm Yagi.

stacking antennas

The basic principles and tables detailed in references 11 and 12 still apply to stacking antennas. However, there is confusion about an article on this subject by Steve Powlishen, K1FO.[13] I used wavelength for the spacings while Steve used inches. To convert wavelengths to inches, multiply the wavelength shown in **table 1**[11] to 82, 53.7, 27.3, and 9.1 inches on 2 meters, 135 cm, 70 cm, and 23 cm, respectively.

There are small differences between the stacking distances shown on Steve's and my charts. As stated in reference 11, the stacking distance is not critical and errors of 5 to 10 percent will not matter, especially if the antennas are not *over* stacked. **Figure 6** in reference 11 clearly shows this relationship. *It is always better to stack on the short rather than the long side.* This means less feedline loss, lower sidelobe levels, and a smaller mechanical structure.

I'm often asked about stacking different frequency antennas on the same boom (reference 11). Generally, the separation from another antenna on a different frequency should be at least one half the stacking distance indicated for each. The theory of effective apertures and aperture overlap is explained in the reference. For instance, if a 2-meter and 70-cm antenna are stacked on the same mast, and the recommended stacking distances are 12 and 6 feet, respectively, the 2-meter antenna should be spaced at least 6 feet from the 70-cm antenna and the 70-cm antenna at least 3 feet from the 2-meter antenna.

This may be too great a distance but there are ways to enhance spacing. One antenna could be on the main mast and the other mounted on a stacking frame to the side of the affected antennas. Different frequency antennas could be placed at other locations on the mast.

I prefer to place my 2-meter and 135-cm antennas at the top of the mast and the higher frequency antennas at the bottom or center. Thus feedlines are shorter on the antennas that would normally have greater feedline losses. If a 6-meter antenna is used, place it at the bottom, and keep it away from the 2-meter antennas. Because of large frequency differences, very little interaction should be noted between the higher frequency antennas.

If you are pressed for space, use one-half wavelength at the lowest frequency, which for a 2-meter antenna equals 40 inches, the minimum recommended distance. Before stacking antennas, draw the typical physical apertures on graph paper to visualize potential interactions.

There are simple tests to check performance after stacking antennas of dissimilar frequency. First, see that the VSWR of each antenna does not increase noticeably, then inspect the radiation pattern to be sure it is similar to what you'd expect when the antenna is mounted alone.

Another letter questions the length of phasing line (reference 12). For best power distribution, keep the phasing line length at odd multiples of quarter wavelengths. Figure the measurement of the phasing line and lengthen or shorten slightly to fit. Don't forget to consider the dielectric constant of the phasing lines to determine its length.

receivers

Readers have asked about the noise figures of commercial rigs. The majority of transceivers I've measured were over two or three years old and in the 6-to-8 dB noise figure region; they often need an external preamplifier for serious DXing.

Part of the reason for the higher noise figures is input switching, which often uses lossier solid-state switching instead of mechanical relays. Internal convenience switching and small diameter coaxial cable often add additional losses. Dynamic range is a consideration since low noise figures require moderate-to-high gain ahead of the first stage of selectivity. Then there are those terrible UHF input connectors!

A problem with many commercial transceivers is that, for economic reasons, they often employ a low first i-f such as 10.7 MHz. Additional input filtering is required to effectively suppress images and this often adds loss. The newer transceivers sport lower noise figures, typically 2 to 3 dB.

The subject of IMD is seldom given enough attention. Receivers and the later stages must be protected from large signals even out of band. This is particularly troublesome where large RF emitters such as local FM or TV transmitters are present. Gary Field, WA1GRC, recently revised his RF CAD program.[7] It now includes a quick IMD analysis and printout with up to 50 input emitters.

*Rutland Arrays, 1703 Warren Street, New Cumberland, PA 17070.

If you require an external preamplifier, try to use one that can be bypassed just in case a local signal or IMD overloads your transceiver. For EME operation, an external preamplifier is required.

One reader rightly chided me for not adequately treating the transmission line losses ahead of the preamplifier. When very low noise figure preamplifiers are used in a quiet environment such as EME or above 220 MHz, and the preamplifier is not mounted right at the antenna with little or no transmission line losses ahead of it, some serious noise temperature increases can occur. This is a separate subject in itself and it will be discussed in a later column.

transmitters

There still seems to be much interest in high-power amplifiers. There aren't many to choose from and they are expensive. 8877s are now well over $500 and prices are rising. Older, more available tubes such as the 7213 and 4CX1000 are of interest but straightforward designs are still scarce.

The FAA surplus AM6154 and AM6155s for 144 through 432 MHz[14] have just about disappeared except when resold by another Amateur. One problem with this rig is the unavailability of 8930 tube replacements. Don Cook, K1DPP, and Dave Hackford, N3CX, have taken a different tack. They have machined reducer rings so that a 4CX250B tube can be substituted for the 8930. The only penalty is a reduction in output power of about 25 percent.

Some of you are interested in the use of microwave oven magnatrons. These ovens nominally operate as an unlocked pulsed oscillator in the 2400-2450 MHz frequency range, the upper segment of the United States 13-cm Amateur band. Amateurs would like to somehow phase or frequency lock the magnatrons.

I've discussed this subject with Hank Cross, W1OOP, who experimented with these ovens for industrial purposes. He notes that the magnatrons used are very difficult to move in frequency, even minimally, because of the waveguide and coupling probe design.

Furthermore, microwave ovens are designed for pulse operation and the dc voltage is generally provided by a nonfiltered half-wave rectifier. Conduction usually occurs above 1000 volts. Consequently, they would probably only be good for 75-150 watts of actual CW RF output in the 2400-2450 MHz range. Until someone can prove otherwise, your time might be wasted pursuing this type of amplifier.

propagation

Whenever Amateurs gather, radio propagation comes up. Amateurs have a unique ability to exploit radio wave propagation due to the large numbers of distributed stations.

Many thanks to Dennis L. Harrsager, N7DH, who pointed out that the constants I used in the equations for path loss on line-of-sight communications were in error.[15] I checked my file and sure enough, Dennis was right. The correct constants are 36.6 (**eqn. 1** for miles) and 32.45 (**eqn. 2** for kilometers).

Thanks also to Len Sheer, W7WRQ, for reminding me that the first radar used for EME communications[16] was not commercial but U.S. Army radar.

Finally, with the increase in solar activity as solar cycle 22 begins, there are more opportunities for long haul DX on 6 meters and transequatorial propagation on the other VHF bands. Six-meter operators will be glad to know that Norwegian stations, LA, now have 6-meter privileges (with low effective radiated power). I've learned that the Madeira Islands, CT3, and Greece, SV0, are now authorized to operate on 6 meters. Many other countries, especially in Europe, are seeking operating privileges on 6 meters now that many TV stations have abandoned channels in this frequency region.

QSLs

Recently someone suggested that I advocate a QSL card without the *QSO confirmed* or *confirming QSO*. I guess he was referring to the sample QSL shown in last June's column[2]. Until his note, I hadn't noticed that the printer didn't include all the information on my portable QSL.

I send filled-out QSLs for valid two-way contact only if I can determine from my log that I was active at that time and frequency. In the case of SWLs, I make it very clear on the QSL that it is *not* confirming a two-way contact. As a reminder,[3] always use UTC dates and time.

construction

I sometimes get requests for sources of printed circuit boards. Unfortunately, I do not have the resources to produce them. Please let me know if you want to volunteer to make up printed circuit boards for any of the circuits published in this column.

Until such time, I will continue to build most of my circuits in self-contained shielded enclosures using double-sided printed circuit material for the ground plane. This method is easy and effective even up through the UHF bands.

product reviews

This column is primarily aimed at the experimenter who builds some of his own gear, so I will probably continue to recommend homebrew gear with a smattering of recommendations where commerical gear is appropriate. If there are specific items that you'd like reviewed, please let me know.

computers in the ham shack

Without a doubt, one of the most important recent innovations for the Radio Amateur is the personal computer. At first it was primarily used for simple calculations and repetitive operations. Nowadays it's being used for logging, word processing sending/receiving Morse/RTTY/Packet, propagation and satellite predictions, schematic layout, and printed circuit board generation. Looks as if we'll all have to adapt to the personal computer!

summary

This month's column was sort of a *potpourri*. Hope I've answered some of your questions and cleared up any misunderstandings. I'm always receptive to new ideas and suggestions on topics or how I can improve the column. Please let me know.

acknowledgments

Although many shall remain anonymous, thanks to all those who wrote to me either with questions, suggestions, or constuctive criticism. Without your support, this column would not be possible.

important VHF/UHF events:

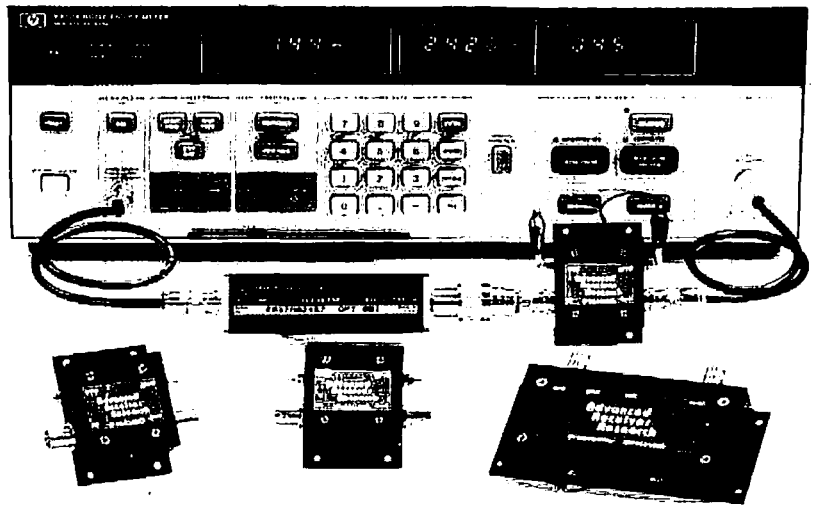
February 17	*EME perigee*
February 17	*New moon*
March 16	*EME perigee*
March 18	*New moon (eclipse of the sun)*
March 21	*+ 2 weeks. Optimum time for TE propagation.*

references

1. Joe Reisert, W1JR, VHF UHF World-Improving Meteor Scatter Communications, *ham radio*, June 1984, page 82.
2. Joe Reisert, W1JR, VHF UHF World-Meteor Scatter Communications, *ham radio*, June 1986, page 68.
3. Joe Reisert, W1JR, VHF UHF World-Operating a VHF/UHF Microwave Station, *ham radio*, July 1987, page 38.
4. Joe Reisert, W1JR, VHF UHF World-Broadband Amplifiers in Receiver Design, *ham radio*, November 1986, page 91.
5. Joe Reisert, W1JR, VHF/UHF World-Low Noise Receiver Update-Part 1, *ham radio*, November 1987, page 77.
6. Joe Reisert, W1JR, VHF UHF World-Propagation Update, *ham radio*, July 1985, page 86.
7. Joe Reisert, W1JR, and Gary Field, WA1GRC, RF CAD Electronics Design Program, version 3.71, available from *ham radio* Bookstore: $39.50 plus $3.50 shipping and handling.
8. Joe Reisert, W1JR, VHF UHF World-Microwave Portable Operation, *ham radio*, June 1987, page 75.
9. Joe Reisert, W1JR, VHF/UHF World-Optimized 2 and 6-meter Yagis, *ham radio*, May 1987, page 92.
10. Joe Reisert, W1JR, VHF UHF World-A High Gain 70-cm Yagi, *ham radio*, May 1987, page 92.
11. Joe Reisert, W1JR, VHF UHF World-Stacking Antennas: Part 1, *ham radio*, April 1985, page 129.
12. Joe Reisert, W1JR, VHF/UHF World-Stacking Antennas: Part 2, *ham radio*, May 1985, page 95.
13. Steve Powlishen, K1FO, Stacking Yagis is a Science, *ham radio*, May 1985, page 18.
14. Joe Reisert, W1JR, VHF UHF World-High Power Amplifiers: Part 2, *ham radio*, February 1985, page 38.
15. Joe Reisert, W1JR, VHF UHF World-Microwave and Millimeter-Wave Propagation: Part 1, *ham radio*, July 1986, page 82.
16. Joe Reisert, W1JR, VHF/UHF World-Minimum Requirements for 2 Meter EME: Part 1, *ham radio*, August 1987, page 39.

ham radio

High Performance vhf/uhf preamps



Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	$29.95
P50VD	50-54	<1.3	15	0	DGFET	$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	$79.95
P144VD	144-148	<1.5	15	0	DGFET	$29.95
P144VDA	144-148	<1.0	15	0	DGFET	$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	$79.95
P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	$79.95
Inline (rl switched)						
SP28VD	28-30	<1.2	15	0	DGFET	$59.95
SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$87.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$62.95
SP432VDA	420-450	<1.2	17	−20	Bipolar	$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

Every preamplifier is precision aligned on ARR's Hewlett Packard HP8970A/HP346A state-of-the-art noise figure meter. RX only preamplifiers are for receive applications only. Inline preamplifiers are rl switched (for use with transceivers) and handle 25 watts transmitter power. Mount inline preamplifiers between transceiver and power amplifier for high power applications. Other amateur, commercial and special preamplifiers available in the 1-1000 MHz range. Please include $2 shipping in U.S. and Canada. Connecticut residents add 7-½% sales tax. C.O.D. orders add $2. Air mail to foreign countries add 10%. Order your ARR Rx only or inline preamplifier today and start hearing like never before!

Advanced Receiver Research

Box 1242 • Burlington, CT 06013 • 203 582-9409

119

INDUSTRIAL QUALITY REPLACEMENT BATTERIES FOR COMMUNICATIONS

Nickel-Cadmium,Alkaline,Lithium,etc.

Repair Packs For
ICOM*, KENWOOD, YAESU, SANTEC, AZDEN, TEMPO, CORDLESS PHONES....AND MORE!

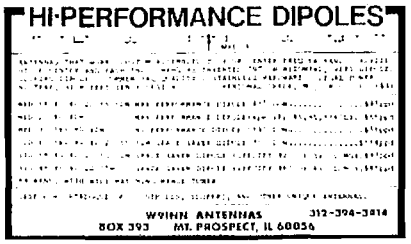
NEW! I.C.E. PACK $49.95

MR. NICAD

E.H. YOST & CO.
EVERETT H. YOST KB9XI
7344 TETIVA RD.
SAUK CITY, WI 53583
ASK FOR OUR CATALOG
(608) 643-3194

121

HI-PERFORMANCE DIPOLES



WYNN ANTENNAS 312-394-3814
BOX 393 MT. PROSPECT, IL 60056

120

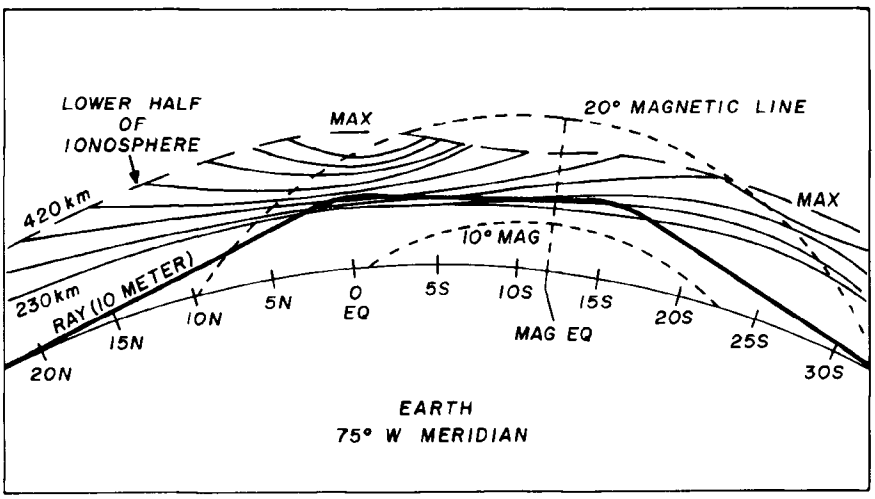
DX FORECASTER

Garth Stonehocker, KØRYW

transequatorial DX update

Transequatorial (TE) propagation is the mode used by signals that cross the equator by other than the normal one-to-three hop ionospheric F, or sporadic E paths. Intermediate ground reflections over a 5000 to 7000 mile path don't occur as shown in the figure's heavy ray traced line representing a 10-meter operating frequency. The indicated contour lines are equidensity electron profiles for the lower half of the ionosphere along the 75 degree west meridian (East Coast of United States and down through western South America). These contours show two maximum regions: one above the geographic equator and the other about 25 degrees south. These two high density areas create the ionospheric tilt that makes TE possible.

Ionospheric scientists have studied the phenomena with vertical and oblique ionosondes to determine the conditions necessary for this to occur and how it can be used in communications. The diurnal conditions are normal during the morning as the sun builds the lower ionosphere at the subsolar point. By local noontime the single maximum of ionization that has grown in the F region begins to divide and shift locations, one moving further south and the other to the north. Throughout the afternoon and evening (to about 2000 local time) the electron drift continues to build at ± 15 degrees on either side of the geomagnetic equator, represented by the dotted line and circle segments in the figure. These building conditions are effective only in the wintertime, September through March, the *same* months for both hemispheres (an unusual condition not yet understood). The magnitude — density or maximum usable frequency — of these maxima increases with sunspot number or solar flux. This is further enhanced during geomagnetic disturbances, when electrons from polar solar wind particles also drift up the field lines from the auroral zone associated trough to the geomagnetic equator's maximum areas.



These studies have brought about an understanding of the conditions needed for TE-DX. Transequatorially propagated signals are only 6 to 30 dB weaker than a significantly shorter (up to one eighth the distance) one-hop signal and 8 to 10 dB stronger than a 3-hop signal. The TE signals are not as coherent, fading independently of the usual F region propagation. Hence TE signals are like scatter propagation except for signal strength. To access TE, use a low take-off angle antenna. It should skip the intervening ground reflection and experience horizon focusing that will strengthen the signal. The best TE direction should be a bearing in a direction perpendicular to the geomagnetic equator, although the aspect angle width is about 50 degrees wide. The geomagnetic equator at 75 degrees west is 12 degrees south of the geographic equator (GE). It then curves north to cross the GE at 25 degrees west, becoming north 10 degrees at 0 degrees longitude. That latitude is continued to the Phillipines where it curves down to meet South America, again crossing the GE at about 70 degrees west. I hope you will have opportunities to try TE-DX by springtime before it begins to wane for the summer.

last-minute forecast

The first two weeks of the month are expected to favor the lower frequency bands, 30 through 160 meters, with nighttime DX and some one-hop daytime short skip for intracontinental contacts. The noise levels should be low on these bands. However, expect weak and fading signals around February 8th, 17 to 19th, and 27th. The higher frequency bands should be best

FEBRUARY

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	4:00	20	20	15	15	15	10	10	20	5:00	30	20	15	15	15	10	10	20	6:00	7:00	30	20	15	15	15	10	10	20
0100	5:00	20	20	15	15	15	10	10	20	6:00	30	20	15	15	15	12	10	20	7:00	8:00	30	20	15	15	15	10	10	20
0200	6:00	20	30	15	20	15	12	10	20	7:00	30	30	15	20	15	12	12	20	8:00	9:00	30	30	15	20	15	12	12	20
0300	7:00	20	30	20	20	15	12	12	20	8:00	30	30	20	20	15	15	12	20	9:00	10:00	30	30	20	20	15	15	12	20
0400	9:00	20	30	20	20	15	15	12	20	9:00	40	30	20	20	15	15	15	20	10:00	11:00	40	30	20	20	15	15	15	20
0500	9:00	20	30	20	20	15	15	15	20	10:00	40	30	20	20	15	15	15	20	11:00	12:00	40	30	20	20	20	20	15	20
0600	10:00	20	30	20	20	15	15	15	20	11:00	40	40	20	20	15	20	15	20	12:00	1:00	40*	30	20	20	20	20	20	30
0700	11:00	20	30	20	20	20	20	15	20	12:00	40	40	20	20	20	20	20	30	1:00	2:00	40	40	20	20	20	20	20	30
0800	12:00	20	30	20	20	20	20	20	30	1:00	40	40	20	20	20	20	20	30	2:00	3:00	30	40	20	20	20	20	20	30
0900	1:00	30	40	20	20	20	20	20	30	2:00	30	40	20	20	20	20	20	30	3:00	4:00	30	40	20	20	20	20	20	30
1000	2:00	30	40	20	20	20	20	20	30	3:00	30	40	20	20	20	20	20	30	4:00	5:00	30	40	20	20	20	20	20	30
1100	3:00	30	40	20	20	20	20	20	30	4:00	30	40	20	20	20	20	20	30	5:00	6:00	30	40	20	20	20	20	20	40*
1200	4:00	30	40	20	20	20	20	20	30	5:00	20	30	20	20	20	20	20	40*	6:00	7:00	20	40	20	20	20	20	20	40*
1300	5:00	30	30	20	20	20	20	20	30	6:00	20	30	15	15	20	20	20	40*	7:00	8:00	20	30	15	15	20	20	20	30
1400	6:00	30	30	20	15	20	20	20	30	7:00	20	30	15	15	20	20	20	30	8:00	9:00	20	30	15	15	20	20	20	30
1500	7:00	30	30	15	15	20	20	20	40*	8:00	20	20	15	15	20	20	20	30	9:00	10:00	20	20	15	15	20	20	20	30
1600	8:00	40*	20	15	12	15	15	20	40*	9:00	20	20	12	12	20	15	20	30	10:00	11:00	20	20	12	12	20	15	20	30
1700	9:00	40	20	15	12	15	15	20	30	10:00	20	20	12	12	15	15	20	30	11:00	12:00	20	20	12	12	15	15	15	30
1800	10:00	40*	20	15	12	15	15	20	30	11:00	20	20	12	10	15	12	20	30	12:00	1:00	20	20	12	10	15	12	15	30
1900	11:00	40	20	15	10	15	15	15	30*	12:00	20	20	12	10	15	12	15	30	1:00	2:00	20	20	10	10	15	12	12	30
2000	12:00	40	20	15	10	15	12	15	20	1:00	30	20	10	10	15	12	12	20	2:00	3:00	20	20	10	10	15	10	10	30
2100	1:00	30	20	12	10	15	12	12	20	2:00	30	20	10	10	15	10	12	20	3:00	4:00	30	20	10	10	15	10	10	20
2200	2:00	30	20	12	10	15	10	12	20	3:00	30	20	10	12	15	10	10	20	4:00	5:00	30	20	12	12	15	10	10	20
2300	3:00	20	20	15	12	15	10	10	20	4:00	30	20	12	12	15	10	10	20	5:00	6:00	30	20	15	15	15	10	10	20

	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
WESTERN USA								
MID USA								
EASTERN USA				CARIBBEAN S. AMERICA				

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next **higher** band for possible openings.

the latter two weeks, particularly the 20 to 25th when the MUFs should be 10 to 15 percent above the median (18 MHz noontime midlatitude estimate). Expect TE openings these weeks with enhancements during disturbed periods.

No significant meteor showers are scheduled to appear in February. A full moon will occur on the 2nd, with its perigee on the 17th.

band-by-band summary

Ten and twelve meters, the highest day-only DX bands, are nearest the MUF for southern hemisphere paths. They will be open most days when the solar flux is above 85 during the 3-to-5 hour period centered on local noon. These bands open on paths toward the east and close toward the west. The paths are up to 2400 miles (4000 km) in single-hop length, and on occasion triple that during evening transequatorial openings.

Fifteen meters, a day-only DX band open most days, will be best when the MUF is slightly above this band in a transition period that occurs right after sunrise and just before sunset. Transequatorial openings will occur, with distances similar to 10 and 12 meters.

Twenty, thirty, and forty meters are both daytime and nighttime DX bands. Twenty is the maximum usable band for DX in the northern directions during the day. In combination with 30 meters, it provides nighttime paths for the day-only bands. Forty meters becomes the main over-the-pole DX nighttime band, with some hours covered by 30 meters.

Eighty and one-sixty meters, the night-only DX bands, exhibit short-skip propagation during daylight hours, then lengthen at dusk. These bands follow the darkness path, opening to the east just before local sunset, swinging more to the north-south near midnight, and ending up in the Pacific areas for a few hours before dawn. On some nights, 80 meters, with its higher signal strengths, will be the best band to use. One-sixty is also expected to provide similarly good conditions.

ham radio

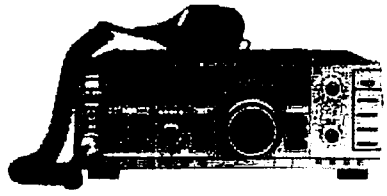
NEW products

two new hf transceivers

Kenwood has announced two new high performance HF transceivers: the TS-140S and the TS-680S. The TS-140S is an all band, all mode, 100 watt HF transceiver with general coverage receiver. The all band, all mode, 100 watt HF TS-680 transceiver, includes a ten watt, six meter section.

The new programmable band marker is useful for staying within the limits of your ham license and prevents out-of-band operation. For contesters, there is a program in the suggested frequencies to prevent QRM to non-participants.

A Morse Code beeper status indicator has been included. The indicator verifies the operating mode with Morse Code characters, signals empty or full memory banks, and lets you know when frequency lock is on.



Other features are: dual digital VFOs, 31 memory channels (ten of which can store receive and transmit frequencies separately for repeater or cross band operation), programmable scanning, and automatic selection of USB or LSB. Kenwood interference reducing circuits: IF shift, dual noise blankers, RIT, RF attenuator, selectable AGC, and FM squelch are also included. Suggested retail price is $899.95 for the TS-140S and $999.95 for the TS-680S.

A complete line of accessories is available. For details contact Kenwood Communications and Test Equipment Group, 2201 E. Dominguez Street, Long Beach, California 90810.

resonators and a new mobile antenna

Hustler, Inc. has introduced two new resonators for use with the H.F. Mobile System. Specifically designed for WARC bands it is completely compatible with your present H.F. Mobile System, using the MO 1, MO 2, or MO-3 mast.

The RM 12, 12 meter resonator has a bandwidth 90-120 kHz under 2:1 or better, a 400 watt rating, for use with the Hustler Mobile H.F. System, for $13.95.

The RM 17, 17 meter resonator with a bandwidth 150 kHz under 2:1 or better and 400 watt rating also for use with the Hustler Mobile H.F. System priced at $19.95.

Hustler's RMX 10 meter Super Mobile antenna has a 1000 watt rating, with a bandwidth 350 kHz under 2:1 or better. Including spring, it is 48 inches tall and can be mounted using the Hustler HLM or TLM. The coil is compatible with the Hustler full size Mobile H.F. System. Available in black, white, or red, the antenna is priced at $31.95.

For further information contact Hustler, Inc., One Newtronics Place, Mineral Wells, Texas 76067.

Circle #301 on Reader Service Card.

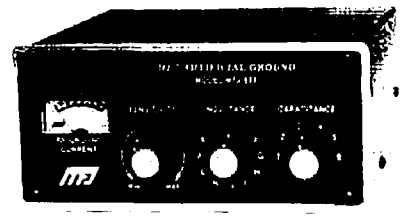
improving rf ground

Don't we all sometimes have problems with not having a good rf ground – problems like rf "hot spots" that "bite" our lips or fingers when we transmit; rf feedback that causes our rigs to quit working on certain bands; excessive rf coupling to ac lines that causes everything to quit working; neighbors screaming about TVI or RFI; computers spewing out gibberish; being unable to talk across town because of extreme ground losses or radiation pattern distortion?

The new MFJ-931 creates an artificial rf ground with just a random length of wire thrown along the floor. It's very effective at placing your rig at or near actual earth ground potential, even if your rig is on a second or higher floor. It can also place a far-away ground, no matter how distant, directly at your rig electrically by tuning out the reactance of the wire that connects your existing ground to your rig.

The MFJ 931 connects between the ground connection of your transmitter or antenna tuner and a random length of wire on the floor. Using its built-in rf ammeter, two knobs adjust for maximum rf ground current; this resonates the random wire, converts it into a tuned counterpoise, and presents an effective low impedance near ground potential to your rig, thus creating an artificial rf ground.

To place a distant ground directly at your radio equipment electrically, simply connect the MFJ-931 between your rig and connecting ground wire. Adjust its two knobs for maximum rf current; this tunes out the reactance of the connecting wire, reduces the electrical ground lead length to virtually zero, and electrically



places your distant ground directly at your rig.

The MFJ-931 covers 1.8 to 30 MHz. Ruggedly built, it's housed in an all-aluminum cabinet with a brushed aluminum front panel, measures 7-1/2 x 3-1/2 x 7 inches, and retails for $79.95.

For additional information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #302 on Reader Service Card.

Kanterm-PC™

Kanterm-PC™ is a new terminal program for IBM PCs and compatibles designed specifically for use with its KPC-4 and KAM dual-port units.

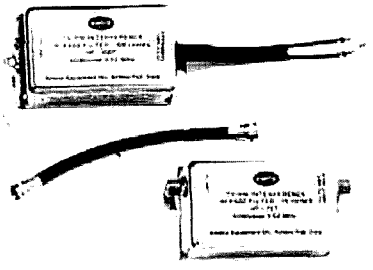
Kanterm-PC features five different selectable screen configurations created to enhance dual port operation. Screen options include the horizontal port split, the vertical port split, hf (port 1) only, VHF (port 2) only, and the standard combined port 1/port 2 full-screen display. All screen displays include a separate transmit display window.

In addition to screen options, Kanterm-PC also features 37 user-loaded buffers of 254 characters each, and a pop-up menu that displays additional program options. Kanterm-PC includes a real-time clock and date display, word wrapping of received text, and many other valuable features.

For further information, contact Kantronics, 1202 East 23 Street, Lawrence, Kansas 66046.

Circle #303 on Reader Service Card.

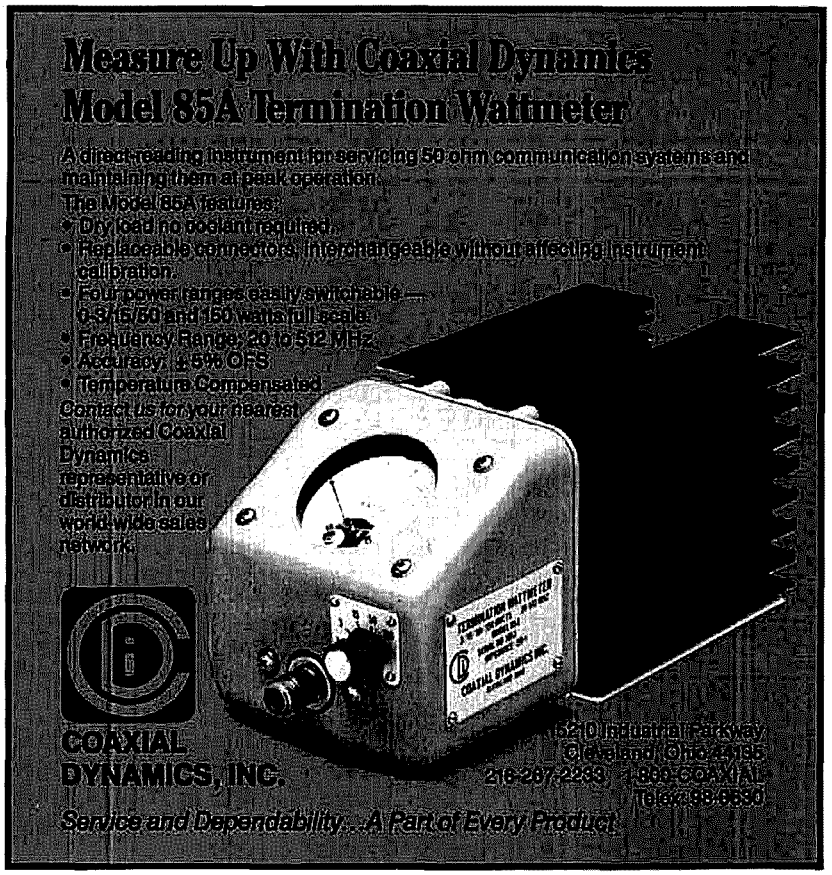
tv/fm interference highpass filters



Ameco has introduced two new tv/fm interference highpass filters. The new models available are HP 75T, for 75 ohm applications, which comes with a length of coaxial cable for easy installation, and HP-300T, for twin-lead applications, which has a twin-lead termination for simple installation. Each filter contains nine shielded sections, with a total of 25 elements in five individually shielded compartments. They provide 70 dB attenuation below 50 MHz. The list price for each is $12.95.

For further information, contact Ameco Equipment Company, 220 East Jericho Turnpike, Mineola, New York 11501.

Circle #304 on Reader Service Card.



117

CONFERENCE PROCEEDINGS

NEW

AMSAT-NA FIFTH Space Symposium

This conference was held in conjunction with the 1987 Amsat Annual Meeting in Southfield, MI, Nov. 6-8, 1987. 11 papers are presented with topics on: trends in spacecraft technology, and space science education, FO-12 mailbox, QRP EME, Phase III-C and Phase IV developments in orbital determination and attitude control. Over 100 pages $12.

21st Central States VHF Society Conference held in Arlington, Texas, July 23-26, 1987. 28 papers covering everything from use of TVRO dishes for moonbounce to a solid state amplifier for 5.7 GHz. 166 pages. $10.

6th ARRL Computer Networking Conference held in Redondo Beach, California, August 29, 1987. The latest concepts on networking, high speed modems and other packet-radio technology are discussed in 30 papers that were prepared for the conference. 174 pages. $10.

OTHER CONFERENCES

Mid-Atlantic VHF Conference. This conference was sponsored by the Mt. Airy VHF Radio Club, Oct. 10-11, 1987. 11 papers cover everything from mountain topping to transceivers for the 3400 and 5600 MHz bands. 120 pages. $10.

MICROWAVE UPDATE 1987 held in Estes Park, Colorado, September 10-13, 1987. 17 papers on equipment, antennas and techniques for 902 MHz through 10 GHz. Much information on construction of 2.3, 3.4 and 5.7 GHz gear. 136 pages. $10.

Please include $2.50 ($3.50 UPS) for shipping and handling.

PUBLISHED BY: THE AMERICAN RADIO RELAY LEAGUE
225 MAIN STREET
NEWINGTON, CT 06111

118

NEW products



cleaning, polishing tool

The Eraser Company has announced the availability of its new Superbrush Cleaner and Burnisher Kit, which contains a Superbrush holder with a coarse-grade FybRglass refill installed and two extra refills made of stainless steel wire and fine-grade FybRglass. Each gives a different cleaning action, ranging from a fine polish to a coarse, sandpaper finish.

Priced at $6.98, the Superbrush may be used to clean, burnish or polish a variety of surfaces. Some of its many uses include removing rust spots, cleaning electrical contacts, roughing surfaces before using epoxy or glue, cleaning lead in stained glass, deburring small metal parts, scrubbing stains off pots and pans, and a number of other household and office uses. A twist-tip control allows the entire length of the refill to be used; replacement refills are available in packs of two.

For details, contact The Eraser Company, Inc., P.O. Box 4961, Olivia Drive, Syracuse, New York 13221.

Circle #305 on Reader Service Card.

tiny TNC-2 announced

Pac-Comm announces a totally redesigned TNC-2 clone, which uses unmodified TAPR TNC-2 software. This new Tiny TNC-2 uses an integrated circuit modem and simplified circuitry to insure reliability, size reduction and a much lower cost. This unit includes as standard features 32k RAM and 32k EPROM, RS 232 and TTL compatibility, watchdog timer, modem disconnect header, switch selectable terminal baud rates and 12V DC operation. The Tiny TNC-2 is approximately 50 percent the size of the original TNC-2. This is not a kit, it's a fully assembled and tested 1200 baud unit, ready for use on 10 meters and VHF. For additional information contact Pac-Comm Packet Radio Systems, Inc., 3652 W. Cypress Street, Tampa, Florida 33607.

Circle #306 on Reader Service Card.

self-teaching Novice package

The *New Novice Voice Class* instructional package from Master Publishing contains everything would-be hams need to learn about, prepare for, and pass the new Novice examination and obtain a license. Two audio cassette tapes and a 112-page book provide all the material covered by the code and theory elements of the Novice Class examination.

The two-sided, 44-minute cassette tapes teach the student how to receive and send 5-WPM CW; the book contains the 302-question pool — with explanations of the answers — from which examiners select 30 questions for the theory examination. Charts, diagrams, and equations illustrate the subject matter. A copy of Form 610 is included, as are directions for the examiners.

The *New Novice Voice Class* package is available in Radio Shack stores for $19.95. For more information, contact Master Publishing, P.O. Box 834158, Richardson, Texas 75083-4158.

Circle #309 on Reader Service Card.

network design, analysis program

RF Notes No. 4 (Network Analysis) from Etron is the sixth in a series of design assist programs for problems frequently encountered in rf and analog design. R, L, and C elements (up to 14 sections) may be entered in schematic diagram form (you actually draw the schematic as you go) or entered directly. Output data is in tabular and graphical form. Graphics plot parameters are user-selectable. Final designs can be saved and retrieved (export/import) in schematic form. Designs from the other Etron *RF Notes* programs (proper version) can be imported for Edit and Analysis.

Priced at $179.00, plus shipping and handling, the fully menu-driven program includes a tutorial section, is color/monochrome selectable, and runs on the IBM PC, PCXT, PCAT, PCjr. (Enhanced), PC/MS DOS 2.1, 256K. A color graphics card (CGA) is required.

For information, contact Etron RF Enterprises, P.O. Box 4042, Diamond Bar, California 91765

Circle #310 on Reader Service Card.

new MS-DOS logbook

QSO PRO from Morlan Software is a high-quality MS-DOS logbook. QSO-PRO was developed for radio amateurs who are committed to keeping track of QSO details. The problem is compounded when keeping track of countries worked and verifying which of those states (or countries) still haven't sent that all-important QSL card.

QSO PRO is designed to be user friendly and stores information on the most often used statistics involved in the average QSO. Additionally, it offers the convenience of REAL TIME LOGGING; PRESET for presetting routine responses; DUPE checks all logged contacts and brings important facts to the current contact. The BROWSE command allows scanning for a specific response using one letter to the entire response.

QSO PRO is self documenting (using help screens). MEMO allows storing personal notes of up to 55 characters about each contact. CURSOR CONTROL gives the ability to easily change any of the information of any contact. TALLY QSO PRO counts QSOs, QSLs sent and QSLs received by state and country. TALLY also ignores any QSOs that are marked as a duplicate.

QSO PRO List Price is $39.95 and is available through the *ham radio* Bookstore (add $3.50 for shipping and handling) or can be ordered directly from Morlan Software, P.O. Box 2400, East Liverpool, Ohio 43920-0400.

Circle #307 on Reader Service Card.

components catalog

A new catalog from Mouser Electronics offers 176 pages featuring 16,000 items including capacitors, potentiometers, resistors, transformers, lamps, switches, batteries, holders, jacks, plugs, speakers, knobs, fuses, semiconductors, hardware, tools, test equipment, relays, cabinets, meters, alligator clips, delay lines, crystals, soldering equipment, integrated circuits, heat sinks, fans, diodes, coils and chokes, connectors, microprocessors, and more.



For a free copy, contact Mouser Electronics, P.O. Box 719, Mansfield, Texas 76063.

Circle #308 on Reader Service Card.

here is the next generation Repeater

2 meters - 220 - 440

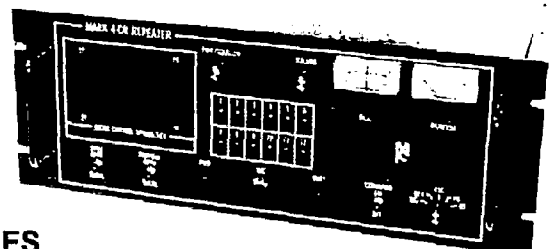
MARK 4CR

The only repeaters and controllers with REAL SPEECH!

No other repeaters or controllers match Mark 4 in capability and features. That's why Mark 4 is the performance leader at amateur and commercial repeater sites around the world. Only Mark 4 gives you Message Master™ real speech • voice readout of received signal strength, deviation, and frequency error • 4-channel receiver voting • clock time announcements and function control • 7-helical filter receiver • extensive phone patch functions. Unlike others, Mark 4 even includes power supply and a handsome cabinet.

Call or write for specifications on the repeater, controller, and receiver winners.

Create messages just by talking. Speak any phrases or words in any languages or dialect and *your own voice* is stored instantly in solid-state memory. Perfect for emergency warnings, club news bulletins, and DX alerts. Create unique ID and tail messages, and the ultimate in a real speech user mailbox — only with a Mark 4.



MICRO CONTROL SPECIALTIES

Division of Kendecom Inc.

23 Elm Park, Groveland, MA 01834 (617) 372-3442

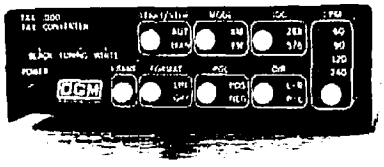
TELEX 4932256 Kendecom

FAX 617-373-7304

116

FAX-1000 fax converter

DGM Electronics, Inc. has just introduced the FAX-1000 Facsimile Converter to its line of quality communications products. The FAX-1000 simply connects between your communications receiver and any Epson graphics compatible printer.



The FAX-1000 allows you to print weather charts, satellite pictures, and press photos. It will copy a-m facsimile signals sent by satellite or lm facsimile signals, which are normally sent on the hf frequencies. It will copy all standard speeds and indices of cooperation. Pictures can be inverted or printed in either direction. A ten segment bar graph allows accurate tuning of the station being copied.

The FAX-1000 can be operated in the automatic or manual mode. In the automatic mode, it will wait for the appropriate signals from the sending station to start, frame, and stop printing. In the manual mode, the operator can start the printing and manually frame the picture. Front-panel LED indicators and pushbuttons make the FAX-1000 easy to operate.

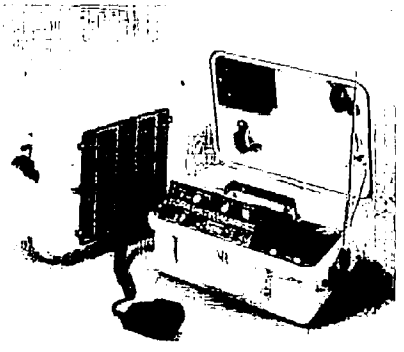
Housed in a compact, RFI proof aluminum enclosure, the FAX 1000 measures only 7 x 2 x 6 inches deep. The unit is powered by a 110 VAC wall transformer (included), and priced at $299. For more information, contact DGM Electronics, Inc., 901 Elmwood Avenue, Beloit, Wisconsin 53511.

Circle #311 on Reader Service Card.

marine radio

The new Vector Radio VR 50 transceiver, priced at $1,295, offers worldwide hf, SSB communications in the Amateur, marine, aircraft, and emergency rescue bands. Powered by a rechargeable battery which is maintained at full charge by a photovoltaic solar panel on top of its waterproof floating case, this self-contained, portable unit measures only 14 x 11 x 6 and weighs 16 pounds.

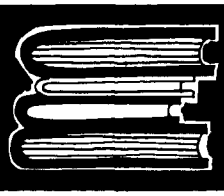
Its 8-foot telescoping whip antenna stores inside the case when not in use. While an internal antenna tuner is built in, the VR-50 may be used with a wide range of auxiliary antennas.



Crystal controlled for "on the money" tuning on a total of 24 channels in the 1.8 to 17-MHz bands, the unit puts out 50 watts PEP on voice and 25 watts on CW (code). Type acceptance by the FCC on marine and aircraft frequencies is expected by November 1987.

For information, contact the Vector Radio Company, 3207 Roymar Road, Oceanside, California 92054.

Circle #312 on Reader Service Card.



ELMER'S NOTEBOOK

Tom McMullen, W1SL

Standing Wave Ratio — what does it mean?

Every radio amateur has at least heard the term, many have measured it and some know what it means.

SWR or VSWR?

SWR or Standing Wave Ratio is a term often used by Amateurs and others in the rf world. But this neat, easy-to-say phrase, doesn't really tell us what kind of waves it describes.

The proper term is VSWR or Voltage Standing Wave Ratio. Some people even try to pronounce it -- something in the order of "vizwahr" comes out. I'm not sure that pronouncing it improves anything, but the electronic world is full of buzz words. However, back to the questions: what is VSWR, how do we get it, and how is it measured?

Figure 1A shows a cross-section of coaxial transmission line terminated with a resistor (or load that appears as one) that matches the impedance of the line. Stick a voltage-sensing probe in the transmission line, move along the line for a considerable fraction of a wavelength at the frequency of your transmitter, and you will get an equal voltage reading at *all* points. This is called a *flat* line. There are no peaks or depressions in the voltage readings from one end of the line to the other. The VSWR is 1:1.

How does it become *unflat?* Let's lay the groundwork for understanding that by looking at some basic dc and ac theory. When you apply voltage to a resistor, current flows through it, and the energy (power) is dissipated as heat. That's the only thing a resistor can do with energy -- turn it into heat and get rid of it by letting the air (water, oil, metal, or some other medium) soak it up. It accepts all the energy you give it.

Applying dc voltage to a coil (inductance) doesn't produce the same result. When current flows in a wire it creates a magnetic field. If that field cuts across any nearby wires, it creates a counter emf. The counter emf tries to make current flow in the opposite direction of the one that created the field and the two currents oppose (buck) each other. Consequently, maximum current flow is delayed while voltage is not and they get out of phase. After the initial surge of current flows through the coil, the field becomes steady and the maximum dc current flow is determined by the resistance of the wire and the applied voltage.

Things get more complex if you apply an ac voltage to an inductor. The magnetic fields build and decrease with each ac cycle. When the field builds in the first quarter of a cycle, it opposes current flow. As the ac voltage decreases during the next 1/4-cycle, the field decreases. A decreasing field creates a current flow that reinforces the original current. During the next two 1/4-cycles the process is repeated and the voltage and direction of current flow reverse, causing the magnetic fields to increase, decrease, and reverse as well. The result is a complex interaction of current flow that slows down and speeds up as determined by the frequency of the ac applied voltage and the reactance of the coil. If the reactance is high enough at the frequency of the ac, almost no current will get through because the magnetic fields are strong enough to oppose it.

To understand the difference between dc and ac power flow remember: with dc maximum voltage and current occur at the same time, and with ac this happens only when the load is a pure resistance (or by the use of electronic trickery appears as one). At all other times, the magnetic fields cause the voltage and current flow peaks to be out of phase. Now, let's see what this has to do with antennas and VSWR.

the antenna as a resistor

An antenna that is exactly the right length for the frequency applied is *resonant.* This antenna accepts all the energy it is given and radiates it into space -- much like the resistor that radiates all its energy as heat. The more you give it, the more it radiates. Such an antenna can be called *resistive* or *matched.*

When the antenna length is not right for the frequency, some of the applied energy is radiated into space but some is used in opposing the current flow by means of magnetic fields, just as with the inductance. These *reactive* anten-

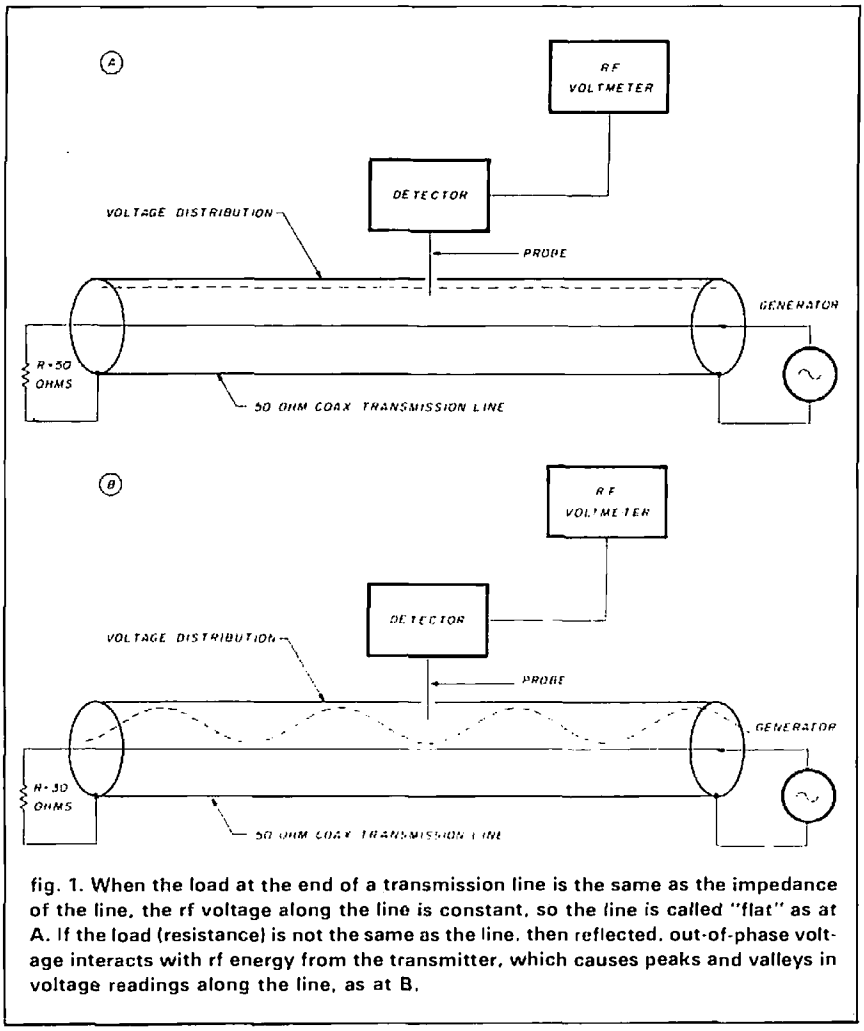


fig. 1. When the load at the end of a transmission line is the same as the impedance of the line, the rf voltage along the line is constant, so the line is called "flat" as at A. If the load (resistance) is not the same as the line, then reflected, out-of-phase voltage interacts with rf energy from the transmitter, which causes peaks and valleys in voltage readings along the line, as at B.

nas cause some energy to be reflected back down the transmission line toward the transmitter and the phase of the reflected energy is not the same as the energy coming from the transmitter. This reflected, out-of-phase wave interacts with the next cycle of energy from the transmitter producing peaks and valleys of voltage along the transmission line. By measuring the voltage with a probe, you get readings with curves like those in **fig. 1B**. To determine the VSWR, use the formula VSWR = Vmax/Vmin. Note that the ratio is always greater than (or equal to) 1, and expressed as 1:1 (for a flat line), 2.3:1 (for moderate SWR), or 11:1 (for a badly mismatched system).

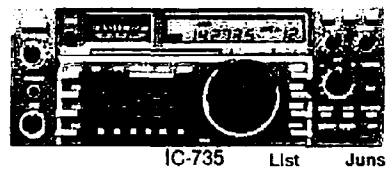
A standard laboratory method of determining VSWR involves moving a probe along a calibrated section of transmission line (either coaxial line or a waveguide), and using the readings for calculations. Commercial SWR meters that use loops to sample rf current in a transmission line are calibrated against this voltage-probe type of instrument (called a *slotted line* because of its construction).

amateur instruments

With this background on VSWR, you can understand the performance of the many commercial and homebrew SWR meters available. It is impractical to keep a slotted line in your backyard to check an 80-meter anten-

800-882-1343

ICOM



IC-735

	List	Juns
IC-761 New Top of Line	2499.00	Call $
IC-735 Gen. Cvg. Xcvr	$999.00	Call $
IC-751A Gen. Cvg. Xcvr	1649.00	Call $
R7000 Gen. Cvg. Rcvr.	1099.00	Call $
R71A Gen Cvg. Rcvr.	949.00	Call $
IC-28A/H FM Mobile 25w/45w	429/459	Call $
IC-37A FM Mobile 25w	499.00	Call $
IC-900 Super Multi-Band Mobile	589.00	Call $
IC-04AT UHF HT	449.00	Call $
IC-48A UHF 45w	459.00	Call $
IC-38A FM Mobile 25w	459.00	Call $
IC-02AT FM HT	399.00	Call $
IC-μ2AT Micro HT	329.00	Call $

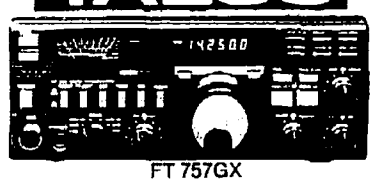
KENWOOD



TS-440S/AT

TS-940SAT Gen. Cvg. Xcvr.	$2249.95	Call $
TS-430S Gen. Cvg. Xcvr	819.95	Call $
TS-711A All Mode Base 25w	899.95	Call $
TR-751A All Mode Mobile 25w	599.95	Call $
TS-440S/AT Gen. Cvg. Xcvr	1199.95	Call $
TM-2530A FM Mobile 25w	429.95	Call $
TM-2550A FM Mobile 45w	469.95	Call $
TM-2570A FM Mobile 70w	559.95	Call $
TH-205 AT, NEW 2m HT	259.95	Call $
TH-215A, 2m HT Has It All	349.95	Call $
TH21BT 2M HT	259.95	Call $
TH31BT 220 HT	269.95	Call $
TM-3530A FM 220 MHz 25w	449.95	Call $

YAESU



FT 757GX

FT-757 GX Gen Cvg. Xcvr.	$995.00	Call $
FT-767 4 Band New	1895.00	Call $
FT-211 RH	459.95	Call $
FT-290R All Mode Portable	579.95	Call $
FT-23 R/TT Mini HT	299.95	Call $
FT-209RH RM Handheld 5w	359.95	Call $
FT-726R All Mode Xcvr.	1095.95	Call $
FT-727R 2M/70CM HT	479.95	Call $
FT2700RH 2M/70CM 25w	599.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

111

na; it would have to be more than 65 feet long and even on the UHF bands is a slow, unwieldy tool. Also, they are made to work with only a few milliwatts of power. The current-pickup-loop type is by far the most common instrument available though some meters use a bridge circuit. Both types sample energy in a very small portion of a wavelength, translating that energy into a meter reading using diodes and resistors to create dc from the rf energy that is picked up. **Figure 2** shows the basic circuitry of two types of current-loop devices and one bridge type. None of them approach the accuracy of a slotted line, but are more than adequate for our purposes.

There are three steps to take when checking out your antenna/feedline/transmitter system. First tune your transmitter with the power/SWR meter connected between it and a good 50-ohm dummy load (assuming you are using 50-ohm coaxial cable*). Second connect the dummy load at the far end of your transmission line and check the power and SWR again. If your cable is good, the reading should be the same as when the dummy load was near the transmitter. If not, your cable is not as good as the salesman said it was. Finally, if the cable checks out, connect the antenna. Any reflected power (SWR) that shows up now indicates that the antenna is not matched. Don't get excited if there is some — few antennas are totally resistive and equal to the transmission line characteristic impedance. A ratio of 1.5:1, 2:1, or more can be tolerated. Check the instruction book for your transmitter's limitations. The SWR you can live with is usually determined by what the final amplifier stage can handle and many solid-state units shut down before it gets high enough to do any damage.

If you want to be a purist, check the transmission line with the power/SWR meter after testing it with the dummy load. By comparing the power readings at both ends, you will see how much is being lost in the cable. Some power is lost because of the wire's resistance, but more is lost if the cable has poor quality dielectric or has been contaminated with moisture or pollution. After you have this bit of good (or bad) news, keep the meter at the far end of the transmision line and check the antenna SWR right on the spot. Be careful here; rf burns can be nasty. You can do all this at relatively low power if your meter is sensitive enough. To keep from annoying fellow occupants on the band, use the lowest power possible; preferably when the band is not open or fairly inactive.

How can an SWR meter fool you into thinking all is well? The voltage and current at the current pick-up point is of such amplitude and phase that it makes the SWR look right and you assume the line is matched. But you notice that the transmitter doesn't load just right, is putting out lower power, or the tuning is super critical. To troubleshoot the problem, add or remove a section of transmission line and see if the SWR reading changes.

*We call it 50-ohm cable, but the impedance is usually closer to 52.5 ohms for most coaxial line.

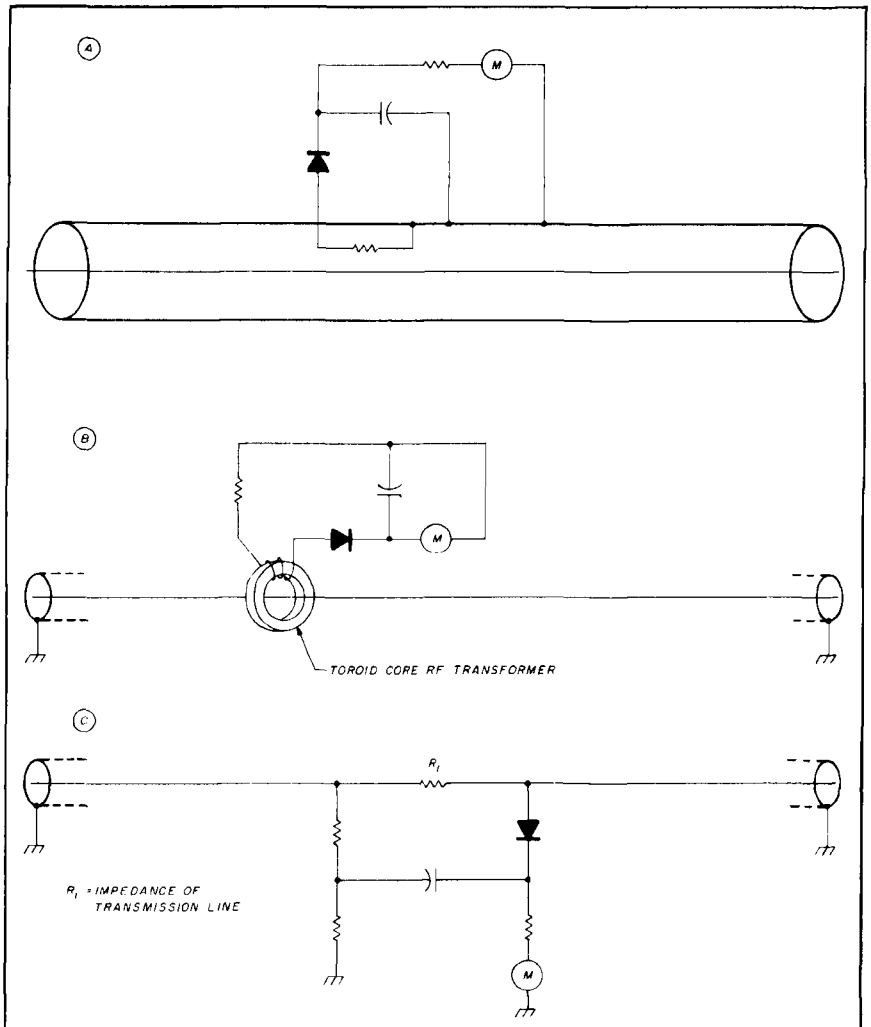


fig. 2. Most common SWR meters used by Amateurs have a current-pick-up loop to sample the rf current in the transmission line. Two types of current-sensing circuits, in simplified form, are shown at A and B. Shown at C is a bridge type of circuit used in some instruments. By adding more components and a switch, any of these circuits can be used to read forward power or reflected power.

flea market

RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance**. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

TEST EQUIPMENT WANTED. Don't wait — we'll pay cash for LATE MODEL HP, Tek, etc. Call Glenn, N7EPK, at Skagitronics Co. (800) 356-TRON.

HAMLOG COMPUTER PROGRAMS. 17 modules auto-logs, sorts 7-band WAS, DXCC. Full features. Apple $19.95, IBM or CP/M $24.95. KA1AWH, POB 2015, Peabody, MA 01960.

TEKTRONIX 7000 scope plug in's wanted: 7A, 7B, 7D, 7S, 7L series. Doug Rygalo, 13117 132 St, Edmonton, Alberta T5L 1R6. Phone (403) 453-1008.

I PAY CASH for new and used vacuum tubes, especially vintage and transmitting types. I also buy vintage audio equipment by Western Electric, Altec, McIntosh, Marantz, Westrex, etc. Randy Nachtrieb, WA6GJA, 6392 Park Avenue, Garden Grove, CA 902645 (714) 897-9351.

WANTED ATLAS 350-XL. N5NM, Box 2169, Santa Fe, NM 87504 (505) 988-2305.

CLEANING HAMSHACK. Ham equipment, test equipment, manuals, radio parts, optics and antique radios/parts. Send business SASE for list. W6IEG, PO Box 1244, Oakhurst, CA 93644. (209) 683-8430.

WANTED: Swan 250, 6 meter (tube) SSB/CW transceiver and power supply. Richard McMahon, PO Box 316, FPO New York 09518.

R-390A Receiver: $115, electronically complete, repairable (government-removed meters, operation unaffected). R-390A parts; info SASE. Professional quality TS-352 Voltohm/Multimeter, AC DC, with leads, manual: $12.50. Mint military spec puff out 12AT7, 6BA6, 6AG5, 6AL5: $10/six. CPRC-26 Infantry Manpack Radio, 6 meter FM, receiver transmitter sections, cabinet, antenna, crystal, handset: $22.50, $42.50/pair. H-251 Military Communications Headphones: $7.50. Add $4.50/piece shipping (59 maximum), except R-390A shipped collect. Baytronics, Box 591, Sandusky, OH 44870.

CAN YOU HELP? Need operating instructions and schematic for John Fluke differential DC voltmeter Model 801. Adrian McManu, VE3AYA, Wyoming, Ontario, Canada NON 1TO.

SB220 OWNERS: Add 160 meters, QSK, +8 additional enhancements. 40 page step by step manual includes parts sources, and 3-500z tech manual. SASE for details. $10 plus $1 postage. WA2SOO, 69 Memorial Place, Elmwood Park, NJ 07407.

TEST EQUIPMENT for SALE. Many useful, quality items. General Radio 1001-A signal generator, lab grade, $100. GR-1650A RCL Impedance bridge, $135. Tektronix 50 MHz plug in units, Exc, 1A1 $100; 1A4 4-trace $150. HP 130B audio scope, $50. HP 412A DC VTVM, Exc, $40. Microwave Equipment HP-618B generator, 3.8-7.6 GHz, $150. FXR C772A, 3.9-8.2G, $75. Alfred 650 Sweep Gen, $200. HP-851B Spectrum Analyzer Display, $100. Boonton 260-A Q Meter, $250. Most have manuals. Large Variac, 22 amps, new, cased, boxed, retails $296, sell $75. UTC commercial grade swinging chokes, 5.25Hy, 5000V, Exc, linear, $25 ea. Micamold capacitors, 2Mf, 4KV, $8 ea. Giant Tektronix service manuals, 465B, 475A $20 ea. List of Test Equipment manuals, SASE. Thermocouple wire, Type J, 18-ft. Joseph Cohen, 200 Woodside, Winthrop, MA 02152 (617) 846-6312.

SOLDERING STATION AND TOOLS. European and American. Free catalog. Robert Mink Import Export, Box 6437R, Fair Haven, NJ 07704. (201) 758-8388.

WANTED TEN-TEC ARGONAUT. N5NM, Box 2169, Santa Fe, NM 87504. (505) 988-2305.

WANTED: K2RIW Amplifier and Power Supply (QST, April, May 1972). Gerald Rose, KB4OGJ, 524 N. Quaker Lane, Alexandria, VA 22304. (703) 370-1880.

ANALOG AND RF CONSULTING for the San Francisco Bay area. Commercial and military circuits and systems. James Long, Ph.D., N6YB (408) 733-8329.

FOR SALE: Ham Radio Magazines, May 1974 to December 1987. Also Astronomy Magazines January 1978 to December 1987. All mint condition, in yearly holders. Make offer. Ralph Albiston, W7IYD, 3029 East 3175 South, Salt Lake City, UT. (801) 484-3859.

1988 PRODUCT AND PRICE LIST of our Kits and Assemblies is now available. Send SASE to A & A Engineering, 2521 W. La Palma, Unit K, Anaheim, CA 92801.

COMMODORE CUSTOM CHIPS FOR C64/128 Computer/Peripherals at low prices, 24 hour delivery: #6510 $9.95, #6526 $9.95, #6567-$14.75, #6581 $12.85, PLA-$12.50, 901 ROMS at $10.95 each and many others... "THE COMMODORE DIAGNOSTICIAN". A complete diagnostic reference chart for fixing Commodore computers, etc. An absolute must for those who want to fix their own computers and save money and down time. $6.95 plus postage...HD Power Supply for C64-$27.95 ...Send for complete chips/parts catalog...VISA, MC...Kasara Inc., 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-642-7634, 800-248-2983 (outside NY) or 914-356-3131.

SUPERFAST MORSE CODE SUPEREASY. Subliminal cassette. $10. Learn Morse Code in 1 hour. Amazing new supereasy technique. $10. Both $17. Moneyback guarantee. Free catalog. SASE. Bahr, 2549-H9 Temple, Palmbay, FL 32905.

UHF PARTS. GaAs fets, mimics, chip caps, trimmer caps, and other builder parts. MGF 1402 @$14.00, MFG 1302 @$10.00. .8-10pf Trimtronics trimmer @$3.75. Porcelain chip caps @$1.75. Orders add $1.00 p+h. SASE for complete list. MICROWAVE COMPONENTS, 11216 Cape Cod, Taylor, MI 48180.

2.4 kHz AM Demodulator with 8 bit A/D and buffer. Copy WEFAX from GOES SATELLITES or APT from NOAA POLAR ORBITING SATELLITES. Created for use with Elmer Schwittek's Multifax 2.0 program. Order #206-KIT $49.95 or assembled and tested board Order #206-ASY $69.95. Add $2.50 shipping per order. For info on all our WEFAX products send SASE to: A & A Engineering, 2521 W. LaPalma, Unit K, Anaheim, CA 92801. (714) 952-2114.

NJ-NJ-NJ-NJ-NJ-NJ-NJ-NJ A Full-Service Ham-SWL-CB-Scanner store in NJ. Discount Grand Opening Prices. Top performing radio systems for every budget. New 10 meter and VHF/UHF rigs. ARRL, Amphenol, Astatic, Astron, Azden, B&W, Bilal Belden 9913, Butternut, Clear Channel, KLM, Larsen, MFJ, Mirage, Mil Spec Cables, much more. Open M-F 10 AM-9PM, Sat 10 AM-7 PM. Buy and sell used gear and have qualified repair facility. ABARIS SYSTEMS, 276 Oriental Pl, Lyndhurst, NJ 07071 (201) 939-0015.

WA9GFR COMMUNICATIONS SOFTWARE. $15.00 disk contains HF/VHF/UHF/L-Band propagation programs to predict range in miles based on transmitter power, receiver sensitivity, and antenna height & gain. A "must" for designing repeater installations. Also includes Smith Chart impedance matching programs. Commodore 64 or IBM. Lynn Genig, RR1, Monroeville, IN 46773.

SMART BATTERY CHARGER for gell cells or lead acid batteries, by Warren Dion, W1BBH. See June '87QST Magazine for circuit details. Complete kit, nothing else to buy, only $49.95 plus $3.50 s/h. Order #150-KIT A & A Engineering, 2521 W. LaPalma, Unit K, Anaheim, CA 92801.

IBM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging. 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

CHASSIS, CABINET KITS. SASE. K3IWK, 5120 Harmony Grove Road, Dover, PA 17315.

TELEVISION SETS made before 1946, early TV parts, literature wanted for substantial cash. Especially interested in "mirror in the lid" and spinning disc tv's. Finder's fee paid for leads. Arnold Chase, 9 Rnshleigh Road, West Hartford, Conn. 06117. (203) 521-5280.

ENGINEERS request free catalog of Electronics Software. Circuit analysis, filter design, graphics, etc. BV Engineering, 2200 Business Way, Suite 207, Riverside, CA 92501 (714) 781-0252.

SUBCONTRACTORS WANTED by electronics manufacturer to wire small pc boards. Box 498, Greenville, NH 03048.

CODE PROGRAMS. Apple C-64/128 3/7 modes graphics lessons. LARESCO, POB 2018-HR, Cabinet City, IL 60409 (312) 891-3279.

RADIO BROADCASTING EQUIPMENT WANTED for parts and rebuilding. Jon Hall, 98 Woodlake Drive, Charlottesville, VA 22901 (804) 978-1220 or (804) 973-8697.

RTTY JOURNAL—Now in our 35th year. Join the circle of RTTY friends from all over the world. Year's subscription to RTTY JOURNAL, $10.00; foreign $15.00. Send to: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

MARCO: Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

COMMODORE REPAIR/CHIPS. We are the oldest/largest Authorized Service Center in the country. Low prices, eg: C-64 repair $39.95 including parts/labor...Commodore Chips at low prices. #6510-$8.95, #6526-$8.95, #6567-$14.45, #6581-$10.95, 82S100/PLA $10.95, 325572-$9.95, 325302-$10.95, #8721-$10.50, #8722-$12.95, 901 ROM Series-$9.95 (for 2 or more chips) and many others..."THE COMMODORE DIAGNOSTICIAN". A complete diagnostic reference chart for fixing Commodore computers, etc. An absolute must for those who want to fix their own computers and save money and down time. $6.95 plus postage...HD Power Supply for C-64-$27.95 +pp...Send for complete chips/parts catalog...We ship worldwide. VISA/MC. Kasara, Inc. 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-248-2983 (Nationwide) or 914-356-3131.

FOR SALE: 1 RACAL Model RA6778 0-30 MHz receiver. Excellent condition. $4200.00 US. Barrie Greenwood, VE3AOA, 248 30th Street, Etobicoke, Ont. Canada M8W 3E1. (416) 253-0708.

ANTENNAS ANTENNAS Austin VHF-UHF Tri-Banders, Yagis HF antenna experimenters kit, books. SASE brings lists. Ed Noll, W3FOJ, POB 75, Chalfont, PA 18914.

HAM LAB PROJECT. Want several pieces HP G-382A variable attenuator. Will consider any repairable condition. K6GOX, PO Box 10, O'Neals, CA 93645 (209) 868-3548 Collect.

30 YEARS PROVIDING QSL's. Full color Old Glory, Cartoon, Also Parchment, Golden Eagle and others. Free samples. SASE appreciated. Rusprint, Rt 1, Box 363-HR, Spring Hill, KS 66083.

YAESU FT-727-R COMPUTER INTERFACE. For info write Gerald Hogsett Consulting, 1581 Woodland, Palo Alto, CA 94303.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224. (213) 774-1255.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

ANNOUNCING a new heavy duty C-64 Commodore replacement power supply especially for the Packet Radio Amateur. The new higher amperage output will now allow for 24 hour continuous "Packet" operation without voltage change or failure which the existing unit can succomb to. This P.S. is an exact physical replacement and will not run hot. $27.95 +pp...VISA/MC. Kasara Inc, 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-248-2983 (Nationwide) or 914-356-3131.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC. ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

February 5-14. NORAC, the North Okanagan Radio Amateur Club, will operate a special event station daily during the Vernon Winter Carnival, Canada's largest winter carnival. Listen for VE7NOR. For a special commemorative certificate send QSL and 2 IRC's or $1.00 to NORAC, Box 1706, Vernon, BC V1T 8C3.

MICHIGAN: February 7. The 18th annual Livonia Amateur Radio Club's Swap 'n Shop, Dearborn Civic Center, Dearborn. 8 AM to 4 PM. ARRL/VEC exams given by the Motor City Radio Club. Plenty of tables, refreshments and free parking. Talk in on I ARC Repeater 144.75/5.35 and 146.52 simplex. For further information SASE to Neil Coffin, WA8GWL, Livonia ARC, POB 2111, Livonia, MI 48151.

MASSACHUSETTS: February 14. Electronics Flea Market sponsored by the Algonquin ARC, Marlboro Middle School Cafeteria, Union Street off Rt 85, Marlboro. 10 AM to 2 PM. Sellers 8 AM. Admission $2.00. Tables $8. advance; $10. door. WHEELCHAIR ACCESSIBLE. For more information Dan, KB1WW (617) 481-1587 or write AARC, Box 258, Marlboro, MA 01752.

MICHIGAN: February 13. The Cherryland ARC will hold its 15th annual Swap N Shop, Immaculate Conception Middle School gymnasium, 218 Vine Street, Traverse City. 8 AM to 1:30 PM. Admission $3.00. Tables $5.00. Talk in on 146.85 repeater. For info contact Mick Glasser, N8DBK, 4102 Peninsular Shrs Dr, Grawn, MI 49637. (616) 276-9203.

OHIO: February 14. The Mansfield Mid-Winter Hamfest. Computer Show, Richland County Fairgrounds, Mansfield. Doors open to public 7 AM. Tickets $3.00 advance; $4.00/door. Tables

(continued to page 103)

Unless the SWR is really what the meter indicates, the reading will get better or worse. You can use this method to temporarily fool the transmitter into providing power to a mismatched transmission line; just vary the line length until it loads properly. This is called *tuning the line,* and it does not change the SWR, but presents the transmitter with a load that it can handle. It is not a good idea to leave it this way, however, as things will be frequency sensitive, and the loading will change with antenna movement and weather.

Does a high SWR cause TVI? This is a trick question. High SWR by itself does not cause TVI but, its effects on other parts of the environment can. For instance if the SWR causes rf to appear on telephone wires, electrical wiring, metal roof gutters, downspouts or tv-antenna lead-in wire, you run a good chance of hearing from your neighbors. Also, the harmonic filter at the transmitter output is designed to work best at one particular impedance and when it sees a mismatch, can let harmonic energy pass through. If the final amplifier in the transmitter is overly sensitive to mismatch, it could start oscillating at some unpredictable frequency. All-in-all, a low SWR is more than just a nice meter reading — it is good operating practice!

power meter update

Not more than a week after I wrapped up last month's column which mentioned rf power meters, I found an ad for some available from a new supplier. These *REVEX* meters cover the frequency range 1.6 to 1300 MHz, power ratings of 1 watt to 5 kW, and include both average and PEP power monitoring. There's also a REVEX Wave Monitor Scope MS1 advertised that allows you to check what's being transmitted from 1.8 to 54 MHz and look at audio frequencies. Check the Amateur-Wholesale Electronics ad on page 76 of the November 1987 *ham radio*.

ham radio

flea market

$5.00 advance, $6.00 door. Talk in W8WE on 146.34/.94. For tickets, tables, SASE by February 4 to Dean Wasse, KB8MG, 1094 Beal Road, Mansfield, OH 44905 or phone (419) 589-2419 after 4 PM EST.

NEW YORK: February 14. LIMARC Hamfest, Electricians Hall, 41 Pinelawn Road, Melville, Long Island. Doors open 9 to 3. Admission $4.00. 4x6 tables, $12. Bring your own $1.50 ft. Advance registration only. Talk in on 146.85. For information Hank Wiener, WB2ALW, 53 Sherrard St., East Hills, NY 11577 (516) 484-4322. Or Mark Nadel, NK2T (516) 796-2366.

GEORGIA: February 27. The Dalton Amateur Radio Club will hold its annual Hamfest, North GA Fairgrounds, Dalton. 9 AM to 3 PM. VE exams will be offered. Suggest reservations for exams. Contact DARC, POB 143, Dalton, GA 30722-0143.

MINNESOTA: February 27. The 7th annual Midwinter Madness Hobby Electronics Show sponsored by the Robbinsdale ARC, Medina Ballroom, Hwy 55, Hamel. 8 AM to 2 PM. Admission $3 advance, $4 door. Flea market tables, $8. 1/2 table $4. FCC exams, large indoor flea market, satellite TV and more. To register SASE with fees to Robbinsdale ARC, POB 22613, Robbinsdale, MN 55422 or call Bob (612) 533-7354.

VIRGINIA: February 28. The Vienna Wireless Society will sponsor its annual Winterfest at the Vienna Community Center, Vienna, VA. Admission $4.00. Talk in on 146.685 or 146.91. For more info contact Dave French, N4KET, 1911 Dalmation Drive, McLean, VA 22101. Tel (703) 356-0996.

INDIANA: February 28. The LaPorte ARC's Winter Hamfest, LaPorte Civic Auditorium, 50 miles SE of Chicago. Donation $3.00. Tables $3.00. Advance reservations accepted. SASE to LPARC, POB 30, LaPorte, IN 46350.

KENTUCKY: March 12. The annual Glasgow Swapfest sponsored by the Mammoth Cave ARC, Cave City Convention Center, Cave City. Starts 8 AM. Admission $3.00. Tables, $3.00 each. Forums and excellent flea market. Talk in on 146.34/.94 and 147.63/.03. For more information N4HCO, 1379 Whites Chapel Road, Glasgow, KY 42141.

NEW YORK: March 13. The 1988 ARRL Hudson Division Convention in conjunction with the WECAFEST 88 Hamfest, Westchester Community College, Valhalla. Sponsored HARC, WECA and WARY-FM, the college's radio station. Activities include forums, ARRL workshops, giant flea market, FCC exams and more. Admission $4.00 at the door. Talk in on 147.06, 146.91, 224.40 MHz repeaters. Exhibitor info: Bob or Sarah Wilson, 7 Soundview Avenue, White Plains, NY 10606. (914) 997-8491. General info: Bob Mossman, NW2L. Program Chairman, (201) 680-1585 or write Great '88, c/o NW2L, 19 Linden Avenue, Bloomfield, NJ 07003.

OPERATING EVENTS

"Things to do . . ."

February 6-8: 1988 New Hampshire QSO Party sponsored by the NH Amateur Radio Association. For information contact Pete Cantara, K1IM, 19 Haverhill St., Hudson, NH 03051.

HAM EXAMS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes, Novice to Extra. Wednesday February 17, 7 PM, MIT Room 1-190, 77 Mass Ave, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hallmann at (617) 646-1641. Exam fee $4.25. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 available from the FCC at Quincy, MA (617) 770-4023.

CHARGE

YOUR CLASSIFIED ADS

to your MC or VISA write or call

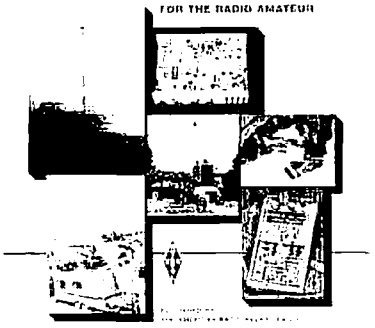
HAM RADIO MAGAZINE

Greenville, NH 03048

(603) 878-1441

THE 1988 ARRL HANDBOOK

FOR THE RADIO AMATEUR



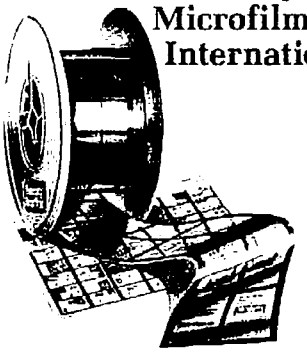
NEW EDITION

The 1988 ARRL Handbook For The Radio Amateur carries on the tradition of the previous editions by presenting 1200 pages of comprehensive information for the radio amateur, engineer, technician and student. Clothbound only. **$21** in the U.S., **$23** in Canada and elsewhere.

THE AMERICAN RADIO RELAY LEAGUE
225 MAIN STREET
NEWINGTON, CT 06111

110

This publication is available in microform from University Microfilms International.



Please send information about these titles:

Name

Company/Institution

Address

City

State Zip

Phone ( )

Call toll-free 800-521-3044. In Michigan, Alaska and Hawaii call collect 313-761-4700. Or mail inquiry to: University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106

MARCH 1988 $2.50

20th Anniversary Issue

Preview of IC-781

ham radio

magazine

high dynamic range mixing



hr

focus on communications technology

ham radio magazine

MARCH 1988

volume 21, number 3

T. H. Tenney, Jr., W1NLB
publisher

Rich Rosen, K2RR
editor-in-chief
and associate publisher

Terry Northup
assistant editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
editorial production

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Rally Dennis, KA1JWF
director of advertising sales

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Farm Color
cover

Siliconix
cover art

ham radio magazine is published monthly by Communications Technology, Inc. Greenville, New Hampshire 03048-0498 Telephone: 603-878-1441

subscription rates

United States
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail)
one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 89

Microfilm copies are available from University Microfilms, International Ann Arbor, Michigan 48106 Order publication number 3076

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1988 by Communications Technology, Inc. Title registered at U.S. Patent Office

Second class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *ham radio* Greenville, New Hampshire 03048-0498

contents

10 high dynamic range mixing with the Si8901
Ed Oxner, KB6QJ

17 the IC-781 ICOM's newest transceiver
J. Craig Clark, Jr., N1ACH

21 optimizing gain in Yagi antennas
Dave Donnelly, K2SS

26 homebrewing equipment from parts to metal work
Paul A. Johnson, W7KBE

29 automatically switched half-octave filters: part 2
Cornell Drentea, WB3JZO and Lee R Watkins

45 frequency calibration using 60 kHz WWVB
John A. Cowan, W4ZPS

53 ham radio techniques: the "radio ground" on 160 meters"
Bill Orr, W6SAI

56 amateur packet radio networking and protocols: part 2
Johnathon L. Mayo, KR3T

65 practically speaking: parametric amplifiers
Joe Carr, K4IPV

71 VHF/UHF world: microwave components and terminology: part 1
Joe Reisert, W1JR

98 Elmer's notebook: transmission lines
Tom McMullen, W1SL

98 advertisers index
9 comments
78 DX forecaster
83 flea market
88 ham mart
81 new products
4 publisher's log
98 reader service
6 reflections



I was just dreaming the other day.

Ya know, a big push is being made to get Novices on 220 MHz. Thousands of dollars are being spent on promotional campaigns, training programs, and the like. Volunteer instructors, the *heroes* of Amateur Radio, have missed countless meals, sleep, and other obligations to bring the message of Amateur Radio to potential new Novices.

As I turn the pages of Amateur magazines from around the world, I see numerous examples of some of the finest solid-state engineering ever done — hf, VHF, UHF and above; multiband, multimode – everything.

But...

In this age of Novice enhancement, to get on 2 and 1.35 meters, you need to buy two different radios.

Why?

For years, radios have been available that cover both 2 and .75 meters. Technically it is relatively easy to do: divide by 3 (440 MHz/3 = 146.67 MHz). A simple tripler circuit in the PLL and a few rf deck modifications and you're ready to go. While in many areas .75 meters is a very useful band, up here in the hinterlands repeater coverage is spotty at best. I tried a multiband radio for a while but 440 really did little for me. On the other hand, 1.35 meters has very interesting possibilities. Coverage is more like 2 meters and there are several very good 220-MHz machines in the area.

With all the advances in solid-state design, it really shouldn't be too hard to come up with a single box to cover both 2 and 1.35 meters. The tricky part will be engineering the PLL. My guess is that the rf deck would be relatively straightforward and easy to build. However, I will leave that to the experts.

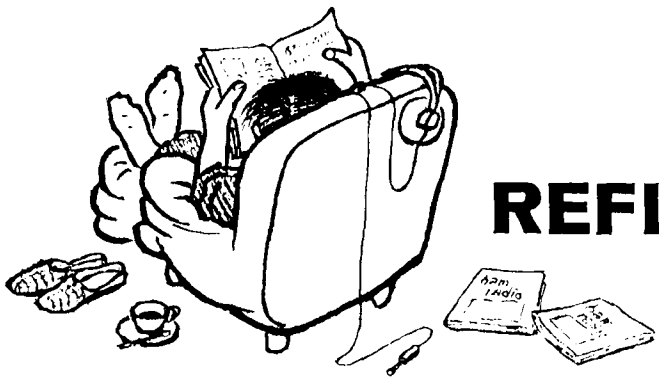
Besides tapping a potentially large market, this new radio would stimulate additional activity on both bands and, through increased usage on 220 MHz, help Novices join in the mainstream of Amateur activity.

We have a responsibility to ensure that Novices learn to be the good hams we want them to be. All too often it has been said that giving Novices 1.35 meter privileges does not enhance the Amateur licensing one bit. Wrong. Novices are using their voice privileges daily around the United States. It has already been shown that they can be integrated into a broader spectrum of Amateur frequencies without a major disruption in overall operation.

How about it, manufacturers? Can you do it? You'll sell a lot of radios and get more of us on 220 MHz. It's a win-win situation.

What do you readers think? I'm very interested. Let me know.

J. Craig Clark, N1ACH
Assistant Publisher



REFLECTIONS

A Passionate Plea

Whatsa matter? Haven't we supplied you with enough information on matching your transmitter to your antenna without having to put a full gallon and a half on the air while loading up? Must you have that *last* milliwatt going into your antenna system? Don't you hear the cries of anguish from 30 guys writhing in pain as they scramble to cut back on their gain controls after having fully advanced it for that extremely weak HL5?

About once a year it seems necessary to remind a few of you that there are other ways to make certain that maximum power transfer occurs during operation, without having to first load up on the air.

Let's take it in steps. First let's find that 50-ohm setting on your amplifier or exciter. This is where a dummy load comes in. There are several good commercial units available or you can make one with a 50 or 100 watt noninductive resistor immersed in a gallon can of oil. Second, connect your transmitter or amplifier to this 50-ohm load (put a power meter in line if you happen to have one) that will take the power for at least a few seconds. Then adjust the tune and load controls until your output and other meter indications are what they should be for the given operating mode and tube ratings. Keep in mind that you don't want your SSB performance to suffer by trying to get out that last possible watt of power. Once you've determined the correct settings mark them with tape or crayon, or jot down the numbers off the apron of the knobs or mechanical readout for each band and segment that you intend to operate.

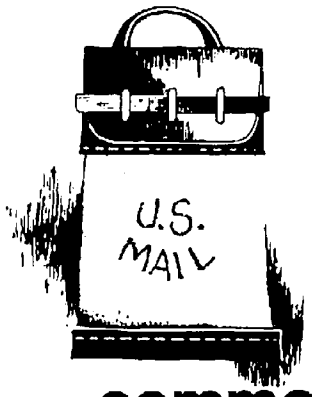
Next, get or make a noise bridge. (We've had several good construction articles like "A Modern Noise Bridge", March 1983, page 50.) Set it for 50 ohms resistive and 0 ohms reactive — or whatever the characteristic impedance of your system is. Connect it to the coaxial output of the transmatch or antenna coupler (the one that's marked 'to the transmitter') and connect the other port of the bridge to your receiver (transceiver). For heaven's sake, don't apply rf power from your transmitter unless you have stock in the noise bridge company. Adjust your antenna coupler until you hear minimum noise in the receiver. Mark down these settings and reconnect your transmitter to your antenna. You should be pretty darn close to match at this point.

I can hear you muttering, "Why did the editor waste all this space on this subject? This is *ham radio* magazine and the majority of readers are technically sharp and know this and other matching procedures forwards and backwards." If this is true, why do I hear so many carriers in the extra and advanced portion of the bands?

One more small point while I've got your attention: *PLEASE* ask first to see if the frequency is occupied before starting a call — CQ, sked, or otherwise. It's possible that while you might not hear the DX station, others do and your bodacious signal will obliterate the weak signals. Recently a certain W2, hell-bent on working a particular contest, called probably 10 CQs in a row without raising any DX while right underneath him an LU2, several JAs, and a Korean station were on. This occurred on 3799 and I'm sure he was oblivious to it. If he had bothered to ask, I can assure you that at least one DX'er would have apprised him of the situation.

I could go on about leaving DX windows clear during contests for very weak signal work, unless of course you are the proverbial shooting fish in the barrel type, but I think you've heard enough from me for this issue. Just please be easy on your fellow ham's ears — those nerves just don't regenerate!

Rich Rosen, K2RR
Editor-in-Chief



comments

transmission beeper hits discordant notes

Dear HR:

Six pages for an end of transmission beeper? Not only are these things annoying, but I would question their legality for use on hf. They certainly do not qualify as A1, A3, A4, A5, F3, F4 or F5. They come closest to A2 (amplitude tone modulated CW) since they convey information via an a-m tone...no different than sending an amplitude modulated "K" for end of transmission.

We have enough noise on our bands without encouraging bleep-bloops. What's wrong with just saying, "over?"

Richard A. Nelson, WBØIKN,
Fort Collins, Colorado 80524

Dear Rich:

I have a bone to pick with you, Rich. The January issue of *ham radio*, somehow conveys to me that your sense of priorities in the selection of articles to be printed in the magazine is all screwed up.

Over the past few weeks, I have been playing around with various CW programs for my C-64. I was never pleased with the results. Being a rank novice at programming, I struggled to get the dash/dot ratios and the word spacings to my satisfaction. When all of a sudden as I was paging through the recent issue of *ham radio*, I find an article that perhaps would give me what I sought a solution to the rather "sloppy" sending of computerized CW programs. You can imagine my disappointment when the program was not listed at the end of the article.

Now I can appreciate your problem about space in the magazine. With your organization no longer providing mailing covers on the magazine, and with the magazine arriving tattered, torn and dog-eared, I can really empathize with you. So I was ready to let sleeping dogs lie, until I continued on through the issue and found the most useless waste of print in years in an article entitled "Build a QSO 'Beeper'".

Now, really Rich, we need this sort of thing on the bands like we need another hole in the head. Can't you imagine what a crowded band like 20 meters or 75 meters would sound like? It would remind me of trying to go to sleep on a hot night when all the crickets are chirping away. Once again I could forgive you for a lapse in good judgment, but not for wasting six good pages on the beeper article when you couldn't spare seven pages for a decent computer CW program!

This sort of thing has put me on hold for a few weeks because I must now wait for a copy of the program from you or pay 8 bucks for a programmed disk.

You must realize by now, that your readership is of a high caliber and will not put up for long with articles of this type.

Tony Sivo, W2FJ
Plainsboro, New Jersey 08536

on the other hand...

Dear HR:

Congratulations on your January 1988 edition. Every article and item was crammed with information at just the right level for we non-engineers, non-appliance operator Amateurs, and hobbyists who still build, experiment, and improve our equipment. Hope you can keep it up.

John Browning, Buena Park, CA 90620

Are you radioACTIVE?



Dean LeMon, KR0V sure is! Dean got active in Amateur Radio when he was 16 years old and earned his Extra Class license in less than four years! "It's a facinating hobby and a great way to meet all kinds of new people from all over the world."

Dean has cerebral palsy and got started in Amateur Radio with help from the Courage HANDI-HAM System. The HANDI-HAM System is an international organization of able-bodied and disabled hams who help people with physical disabilities expand their world through Amateur Radio. The System matches students with one to one helpers, provides instruction material and support, and loans radio equipment.

Isn't it time you got radioACTIVE with the Courage HANDI-HAM System?

Call or write the Courage HANDI-HAM System W0ZSW at Courage Center, 3915 Golden Valley Road, Golden Valley, Minnesota 55422, phone (612) 588-0811.

Are you radioACTIVE?

high dynamic range mixing with the Si8901

Extends intermod HF/VHF performance at lower drive

The dynamic range of a mixer is intimately related to how well its intermodulation products are suppressed, how well the mixer can handle high-level signals, and its overall noise figure. Whether a mixer offers conversion gain or loss is secondary to the benefits derived from a high dynamic range. In fact, conversion gain simply transfers the problems associated with dynamic range from the mixer to subsequent amplifier stages.

Until now, most mixers sporting a high dynamic range have required a correspondingly high local oscillator drive, as shown in the performance comparison in **fig. 1**. The popular diode-ring double-balanced mixer (DBM), shown in **fig. 2**, often requires the local oscillator power to exceed the signal compression level by at least 6 dB.

The Siliconix Si8901 DBM (**fig. 3**) is a monolithic quad-MOSFET ring demodulator especially suited for hf and low VHF operation where, operating as a commutation (switching) mixer, it is capable of two-tone, third-order input intercepts exceeding +37 dBm and a 2-dB signal overload compression and desensitization of +30 dBM — all at a local oscillator drive level of only +17 dBm (50 mW)! An additional benefit of this low local oscillator drive results when, in combination with the traditionally high interport isolation afforded by DBM design, little re-radiated power exits the mixer through the signal port.

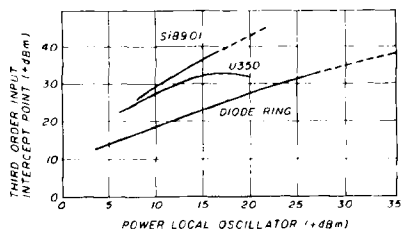


fig. 1. Performance comparison of double-balanced mixers.

The Si8901 is available in the hermetic TO-99 package, suitable for full military applications, as well as in a surface-mount SO-14, which is useful for modern industrial and Amateur applications where high dynamic range is mandatory.

theory of operation — conversion efficiency

Unlike the diode-ring mixer, the commutation mixer relies on the switching action of the quad-MOSFET elements to effect mixing action. Consequently, the Si8901 is, essentially, a pair of switches reversing the phase of the signal at a rate determined by the local oscillator frequency. Ideally, we would expect little noise. Since the MOSFET exhibits a finite on-resistance, the conversion efficiency is expressed as a loss. This loss results from two related factors: first, the $r_{DS}(on)$ of the MOSFETs relative to both the signal and i-f impedances, and second, signal conversion to undesired frequencies.

The effect of $r_{DS}(on)$ on both the signal and the i-f impedances (R_g and R_L, respectively) may be derived from analysis of an equivalent circuit (**fig. 4**), assuming the local oscillator drive is an idealized square wave. The term $4/\pi^2$ is the power function of the Fourier series of an idealized square-wave excitation.

Conversion loss for an ideal mixer with the image and sum frequency (RF + LO) ports shorted may be expressed in terms of r_{ds} (on), R_g, and R_L as follows:

$$L_c = 10\ Log \frac{[(\pi^2/4)\ (R_g + r_{DS(on)}) + R_L + r_{DS(on)}]^2}{\pi^2 R_l R_g} \quad (1)$$

If we let $r_{DS}(on) = 0$ and resistively-terminate the image and sum frequency ports the minimum attainable conversion loss reduces to

$$L_c = 10\ Log\ 4/\pi^2\ dB \quad (2)$$

which computes to L_c = -3.92 dB. In a practical sense we need to add 3.92 dB to the results of **eqn. 1** or **fig. 5** to obtain the true conversion loss.

By Ed Oxner, KB6QJ, Applications Engineer, Siliconix Inc., Santa Clara, California 95054

Equation 1 plotted for various ratios of R_g, R_L, and $r_{DS}(on)$ (**fig. 5**) illustrates how seriously the on-resistance of the MOSFETs affects the conversion loss.

intermodulation distortion

Unbalanced, single-balanced, and double-balanced mixers are distinquished by their ability to reject spurious frequency components selectively, as defined in **table 1**. In the majority of mixer applications, the most damaging intermodulation distortion products (IMD) are those attributed to odd order and, in particular, those identified as the third order (IMD3).

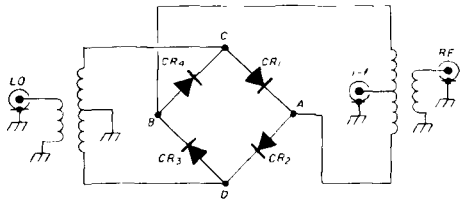


fig. 2. Diode ring double-balanced mixer.

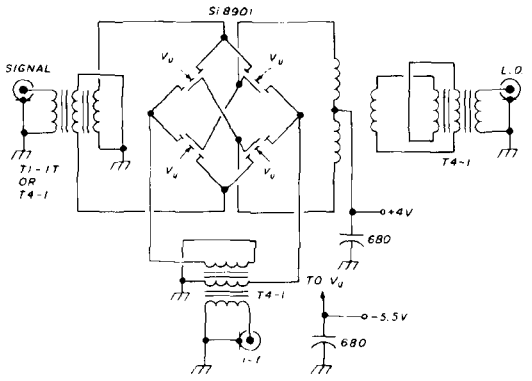


fig. 3. Prototype commutation double-balanced mixer.

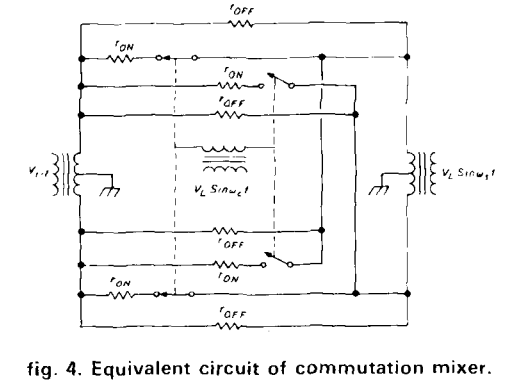


fig. 4. Equivalent circuit of commutation mixer.

Table 1. A comparison of modulation products in single- and double-balanced mixers to the sixth order.

single-balanced	double-balanced
f_s	
$3f_s$	
$5f_s$	
f1 + f2	f1 + f2
f1 + 3f2	f1 + 3f2
f1 + 5f2	f1 + 5f2
2f1 + f2	
3f1 + f2	3f1 + f2
3f1 + 3f2	3f1 + 3f2
4f1 + f2	
5f1 + f2	5f1 + f2

Although the DBM outperforms the single-balanced mixer, a more serious source of intermodulation products results when the local oscillator excitation departs from the idealized square wave. This phenomenon is easily recognized by a careful examination of **fig. 6**, which shows the effect of sinusoidal local oscillator voltage on varying transfer characteristics. Since optimum IMD performance demands that the switches of a commutation mixer operate in a 50-percent duty cycle (i.e., fully on and fully off for equal times), some offset voltage is necessary.

Walker[1] has derived an expression showing the predicted improvement in the relative level of two-tone, third-order IMD as a function of the rise and fall times of the local oscillator waveform.

$$IMD = 20\ Log\ \frac{t_r \omega_{LO} V_s / V_c)^2}{8}\ dB \qquad (3)$$

where V_c is the peak-to-peak local oscillator voltage

V_s is the peak signal voltage

t_r is the rise and fall time of V_c

ω_{LO} is $2\pi f_{LO}$ where f_{LO} is the local oscillator frequency

Equation 3 shows that by lowering R_g (which, in turn, decreases the magnitude of V_S) IMD performance is improved. Likewise, increasing the local oscillator voltage, V_c, improves IMD performance. Finally, if we can provide idealized square-wave excitation, we achieve the perfect mixer! Additionally, we see that low-side injection is more efficient than high-side injection.

Further justification for square-wave local oscillator drive is an additional fault of sinusoidal excitation. Whenever the exciting wave approaches zero crossing at half-period intervals, the FETs, in effect, lose

Table 2. Comparison of ac gate voltage vs. local-oscillator drive between a non-resonant/resonant tank with a loaded Q of 14 (150 MHz frequency).

power in (mW)	non-resonant gate voltage (V)	resonant gate voltage (V)
10	0.20	5.4
20	0.29	7.7
30	0.33	9.4
60	0.44	13.3

their bias, and serious signal voltage overload results in severely degraded IMD performance. The effects of sinusoidal excitation on gate bias are easily seen in **fig. 7**.

building the mixer

Based on the knowledge derived from **eqn. 3**, low source resistance, R_g, and high local oscillator excitation voltage, V_c, are ideal conditions for a mixer. The Si8901, operating as the mixer switch, offers a typical on-resistance of approximately 23 ohms when excited by a gate potential of 15 volts. Using the popular 4:1 i-f output transformer to a 50-ohm preamplifier, ($R_L/r_{DS}(on) \sim 8$), **fig. 5** suggests optimum conversion efficiency with an R_g of 92 ohms. This is contradicted in **eqn. 3**, which shows that optimum IMD performance results with the lowest possible V_s. This result is achieved by lowering R_g. It now becomes clear that a performance tradeoff may be necessary. Either we seek low conversion loss, and with it a low noise figure, or aim for the highest IMD performance. Fortunately, as we seek high performance, the dynamic range will improve since a mismatched signal port has less effect upon the signal-to-noise performance than a matched signal port has upon IMD.

establishing the gate drive

Using the conventional broadband, transmission-line transformer characteristic of the diode-ring DBM requires massive local oscillator drive to effect the required gate voltage needed to satisfy **eqn. 3**. Earlier MOSFET commutation mixers required watts of local oscillator drive to achieve high dynamic range![2]

One obvious means of obtaining a high gate voltage is to use a resonant gate drive. The voltage appearing across the resonant tank, and thus on the gates, may be calculated as

$$V = (PQX)^{1/2} \qquad (4)$$

where P is the local oscillator power delivered to the resonant tank

Q is the loaded Q of the resonant tank

X is the reactance of the gate

Since the gate capacitance of the MOSFETs is voltage dependent, the reactance becomes dependent upon the impressed excitation voltage. To allow this condition would severely degrade the IMD performance of the mixer. However, this reactive dependence on excitation voltage can be minimized using a corn-

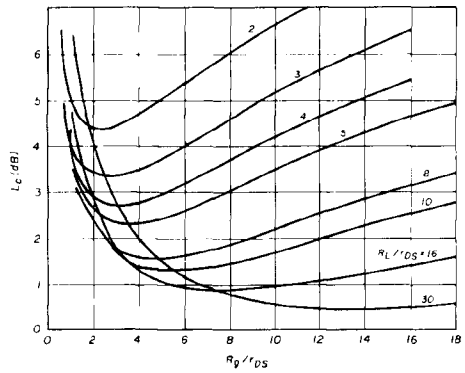


fig. 5. Insertion Loss as a function of r_{DS}, R_L, and R_g

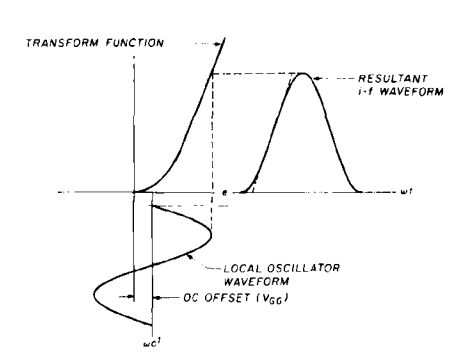


fig. 6. Effect of sinusoidal local-oscillator waveform on i-f linearity.

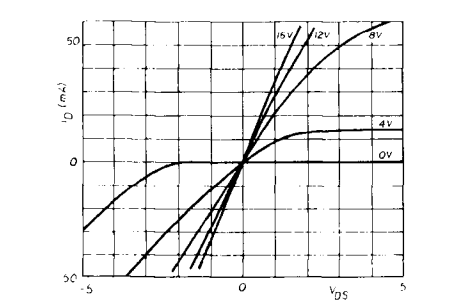


fig. 7. First- and third-quadrant I-E characteristics showing effect of gate voltage leading to large-signal overload distortion.

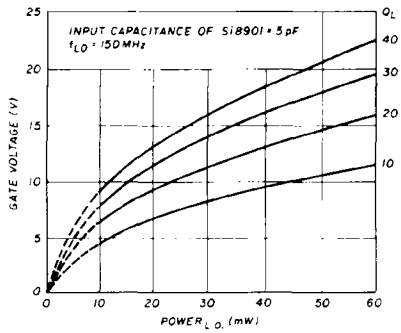


fig. 8. Influence of loaded Q on gate voltage vs. local-oscillator power.

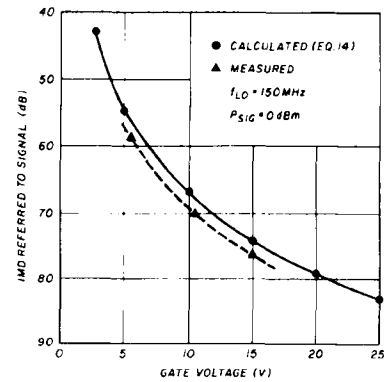


fig. 9. Effect of gate voltage on IMD performance.

bination of gate and substrate biasing. As we saw in **fig. 6**, the offset gate bias helps to achieve the required 50-percent duty cycle for optimum IMD performance.

Table 2 and **fig. 8** offer an interesting comparison between a resonant-gate drive with a loaded *Q* of 14 and conventional drive using a 50 ohm to 200 ohm (100-0-100) 4:1 transformer. The full impact of a high-voltage gate drive can be seen in **fig. 9**, which shows close agreement between the calculated (**eqn. 3**) and the measured IMD.

designing the mixer

Achieving the low signal input impedance can be easily accomplished using the Mini-Circuits T1-1T (1:1) broadband transformer. Likewise, for the i-f output, the Mini-Circuits T4-1 (4:1) does an excellent job.

The principal effort is the resonant gate drive, which necessitates an accurate knowledge of the Si8901's total capacitive loading. The data sheet offers typically 4.4 pF. To ensure good interport isolation, symmetry is critical. If this resonant tank is driven from an asymmetrical local oscillator source (coax), an unbalanced-to-balanced transformer ensures symmetry (see complete mixer schematic shown in **fig. 3**).

performance of the Si8901 commutation mixer

The following tests were performed across the 2-to-30 MHz hf band.

- conversion efficiency (loss)
- two-tone, third-order intercept point
- compression level
- desensitization level
- noise figure

The conversion loss and input intercept point are plotted as a function of local oscillator drive power in **fig. 10**.

The 2-dB compression and desensitization levels appear to contradict what is normally expected based

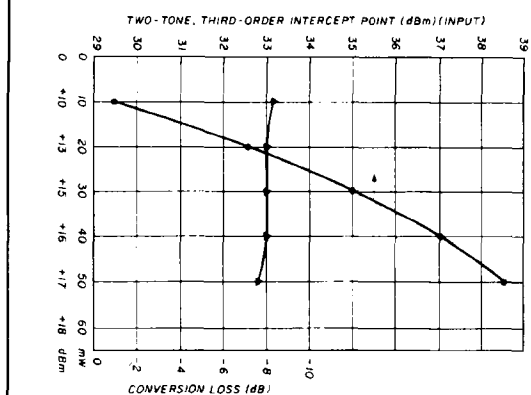


fig. 10 Intercept point and conversion loss.

on the +17-dBm local oscillator drive until we are reminded that the mixer's performance is based on gate voltage, not gate drive expressed as power. Both were measured at +30 dBm. The single-sideband noise figure was 7.95 dBm.

If the design engineer follows the concepts suggested in this note, the Siliconix Si8901 will provide the highest dynamic range of any comparable mixer currently available. Achieving a high gate voltage using a resonant drive does not label the mixer as a narrow-band device. Tank tuning may be accomplished in a number of ways, such as electronic tuning using varactors. It is conceivable that the tank may be the output of an electronically tuned balanced local oscillator circuit.

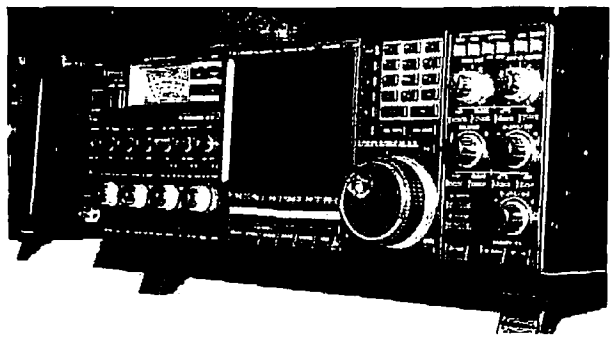
references

1. H.P. Walker, "Sources of Intermodulation in Diode-Ring Mixers," *The Radio and Electronic Engineer*, Vol. 46, No. 5, May 1967, p. 247-255.
2. R.P. Rafuse, "Symmetric MOSFET Mixers of High Dynamic Range," *Digest of Technical Papers*, 1968 International Solid-State Circuits Conference, p. 122-123.

ham radio

HR EXCLUSIVE

provides new dimension
in signal reception

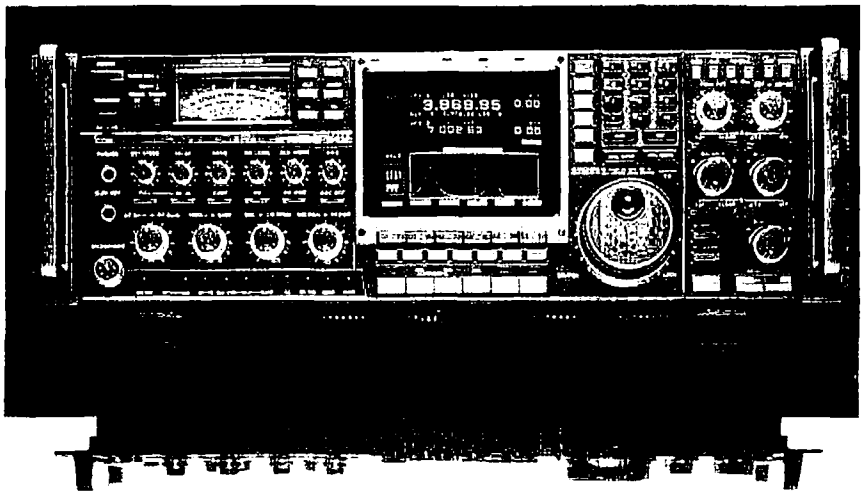


the IC-781

ICOM's newest transceiver

By J. Craig Clark, Jr., N1ACH, Assistant Publisher, *ham radio*.

Rumors have been flying for the past few months about a major new radio on the way from Japan. We've carefully watched the Japanese *CQ* *Ham Radio*, the largest ham radio magazine in the world, for a glimpse of this interesting new product. Little has slipped through — a whisper here, a hushed conversation there — snippets that when put together yield tantalizingly little about what it actually is.



By now, you know that ICOM has announced its new IC-781 transceiver. Ads first appeared in February issues of American Ham magazines. ICOM has also been showing the unit at various dealers around the country in conjunction with ICOM DAY promotions. When I found that the new ICOM IC-781 was going to be at Hamtronics in Trevose, PA, in early December, I decided to get a hands-on demonstration.

A few days later, I found myself standing in front of the store in Trevose. Though it was still pretty early, a fair crowd had already arrived and was hovering around the IC-781. After making my way through the throng and introducing myself to the Hamtronics gang and Evelyn Garrison and Mike Vincent from ICOM, I got my first look at the radio.

Let me give you an overview of the radio's unique features. While the price is rather steep, (about $7,000) one thing to remember is that an innovative radio like this has a trickle-down effect within the industry. If you look back about 20 years to the Signal One CX-7 (at the time a quantum leap in transceiver design) and compare it to today's state-of-the-art transceiver, you'll find plenty of parallels. The IC-781 will pave the way for many new features you'll want in your next radio.

The first thing you notice about the IC-781 is its 5-inch CRT display set smack dab in the middle of the radio's front panel. Other than that, it bears a striking physical resemblance to ICOM's IC-761 transceiver. The unique feature of the IC-781 is that it contains a spectrum analyzer which gives you a picture of band occupancy and relative signal strength in 100, 200, and 400-kHz windows centered on your operating frequency. As with a conventional spectrum analyzer, frequency is plotted on the horizontal axis and signal strength on the vertical.

DXers will find this to be a boon in finding pileups as they scan the bands. Big wide blips will indicate hotbeds of activity. Contesters will no longer have to search up and down the band for

clear frequencies to set up a new run. Also, by looking at relative strengths of signals and finding out what areas of the world are coming in the best, you can determine if it's better to look for new multipliers or try to run them.

The multi-function CRT displays VFO A and B frequencies, memory contents and, when connected to an external TU such as the Kantronics KAM, MFJ, or AEA PK-232, the demodulated output of CW, RTTY or other digital modes. This eliminates the need for a bulky external monitor.

But that's not all! In addition to the CRT display features, the IC-781 also has a number of other interesting capabilities.

For example, you can listen on both VFO frequencies simultaneously (while in the same band) and vary audio balance between each. Don't want to miss that rare DX station that's working call zones? Tune the DX station on VFO B, turn the audio balance up enough so you can hear and keep track of his operation, tune VFO A to an open spot and call CQ. When the DX station gets to your call area, switch VFOs and call. Or, when you are working a split frequency pileup, adjust the audio balance between VFOs so you can keep track of both your transmit and receive frequencies. Too many stations calling on your transmit frequency? Slide up 500 Hz without losing track of the DX station and call again. It's that easy.

Another innovation is the twin passband tuning capability. You can tune



the second and third IF separately for double passband tuning or together as an IF shift. Sometimes you want that extra ability to reduce an interfering signal. The double passband control will give you this.

Recognizing that in many cases 90 to 110 watts power output is not enough to fully drive many of the amplifiers now available, ICOM has increased the power output of the IC-781 to a generous 150 watt level. This should be more than enough to drive grounded grid amplifiers to full legal output or provide that extra bit of signal when running "barefoot".

The IC-781 also comes with: built-in switching power supply, automatic "one-button" antenna tuner, keyboard frequency entry control, dual noise blanker with monolithic crystal filter, 99 tunable memories, wide and narrow filters, and an internal iambic keyer at no additional cost.

As you can see by looking at the photos, the IC-781 is a pretty complete radio.

ham radio

INTERFERENCE?

★ Interference Location
★ Stuck Microphones
★ Cable TV Leaks
★ Security Monitoring



★ VHF and UHF Coverage
★ Computer Interface
★ Speech Synthesizer
★ 12 VDC Operation

New Technology (patent pending) converts any VHF or UHF FM receiver into an advanced Doppler shift radio direction finder. Simply plug into receiver's antenna and external speaker jacks. Uses four omnidirectional antennas. Low noise, high sensitivity for weak signal detection. Call or write for full details and prices.

DOPPLER SYSTEMS, INC. P.O. Box 31819 Phoenix, AZ 85046 (602) 488-9755

220

RF POWER TRANSISTORS

We stock a full line of Motorola & Toshiba parts for amateur, marine, and business radio servicing

SEE YOU AT THE ORLANDO CHARLOTTE & DAYTON HAMFESTS

Partial Listing of Popular Transistors

2-30 MHz 12V (28V)*

P N		Rating	Net Ea.	Match Pr.
MRF421	Q	100W	$24.00	$53.00
MRF422*		150W	36.00	78.00
MRF454, A	Q	80W	14.50	32.00
MRF455, A	Q	60W	11.75	26.50
MRF485*		15W	6.00	16.00
MRF492	Q	90W	16.00	35.00
SRF2072	Q	65W	12.75	28.50
SRF3662	Q	110W	24.00	53.00
SRF3775	Q	75W	13.00	29.00
SRF3795	Q	90W	15.50	34.00
SRF3800	Q	100W	17.50	38.00
2SC2290	Q	80W	16.75	39.50
2SC2879	Q	100W	22.00	48.00

Q *Selected High Gain Matched Quads Available*

VHF UHF TRANSISTORS 12V.

	Rating	MHz	Net Ea.	Match Pr.
MRF245	80W	136-174	27.50	61.00
MRF247	75W	136-174	26.00	58.00
MRF248	80W	136-174	33.00	71.00
MRF641	15W	407-512	18.00	42.00
MRF644	25W	407-512	21.00	46.00
MRF646	40W	407-512	25.00	54.00
MRF648	60W	407-512	31.00	66.00
2N6080	4W	136-174	6.25	—
2N6081	15W	136-174	8.00	—
2N6082	25W	136-174	9.50	—
2N6083	30W	136-174	9.75	24.00
2N6084	40W	136-174	11.50	28.00

PARTIAL LISTING OF MISC TRANSISTORS

MRF134	$16.00	MRF515	2.50
MRF136	21.00	MRF607	2.50
MRF137	24.00	MRF630	4.25
MRF138	35.00	MRF846	43.50
MRF174	80.00	MRF1946,A	14.00
MRF208	11.50	CD2545	16.00
MRF212	16.00	SD1278-1	17.75
MRF221	11.00	2N3553	2.29
MRF224	13.50	2N3866	1.25
MRF237	2.70	2N4427	1.25
MRF238	12.50	2N5589	7.25
MRF239	14.00	2N5590	10.00
MRF240	15.00	2N5591	13.50
MRF260	7.00	2N5641	9.50
MRF261	8.00	2N5642	13.75
MRF262	8.75	2N5643	15.00
MRF264	12.50	2N5945	10.00
MRF309	29.75	2N5946	12.00
MRF317	56.00	2SC1946,A	15.00
MRF406	12.00	2SC1947	9.75
MRF433	11.00	2SC2075	3.00
MRF449	12.50	2SC2097	28.00
MRF450	13.50	2SC2509	9.00
MRF453	15.00	2SC2640	15.00
MRF458	20.00	2SC2641	16.00
MRF475	3.00	*OUTPUT MODULES*	
MRF476	2.75	SAU4	55.00
MRF477	11.75	SAU17A	50.00
MRF479	10.00	SAV6	42.50
MRF492A	18.75	SAV7	42.50
MRF497	14.25	SAV15	48.00
40582	7.50	M57712, M57733	use SAV7
NE41137	2.50	M57737, SC1019	

Hi-Gain, Matched, and Selected Parts Available

We stock RF Power transistors for Atlas, KLM, Collins, Yaesu, Kenwood, Cubic, Mirage, Motorola, Heathkit, Regency, Johnson, Icom, Drake, TWC, Wilson, GE, etc. Cross-reference on CD, PT, SD, SRF, JO, and 2SC P Ns.

Quantity Pricing Available Foreign Orders Accepted

Shipping Handling $5.00 COD VISA MC

Orders received by 1 PM PST shipped UPS same day. Next day UPS delivery available

ORDER DESK ONLY — NO TECHNICAL
(800) 854-1927

ORDER LINE and or TECH HELP
(619) 744-0728

FAX (619) 744-1943

RF PARTS
1320 Grand Avenue
San Marcos, CA 92069

optimizing gain on Yagi antennas

Examination of "short" boom Yagi reveals surprising results.

In the recent past, Yagi antenna construction was as much folklore, superstition, and magic as it was science and engineering. For example, the guidelines for constructing a Yagi antenna provided in the ARRL's 1980 *Antenna Handbook*[1] include a general table of ranges for "optimum" element spacing, but not a formula for determining optimum element lengths. Would an antenna built according to this data really be "optimum?"

Computer modeling of Yagi antennas provides a means of answering this question by allowing us to examine the effects of element length and spacing perturbation and by providing an efficient and reproducible means of calculating gain and pattern. Even with some major simplifying assumptions about element interactions and element self-impedance, the result of Yagi modeling predicts the results from the antenna test range.[7] Two previous papers examined the change in forward gain with different taper regimens — i.e., all directors the same length, all directors getting shorter towards the front, all directors longer towards the front.[2,5] Although a taper regimen may offer a slight advantage, the difference is almost vanishingly small. For example, maximum gain on a 3.44-wavelength boom Yagi with no director taper was 15.601 dBi, and the maximum gain with an "optimum" director taper was 15.618 dBi.[2] However, these previous studies imposed a fixed geometric relationship between the directors, although the only rationale for this is aesthetics. In his thesis work, Dr. Chen found that Yagi antennas maximized for forward gain smoothly converged to a single unique solution and, from his examples, director lengths had no apparent geometric relationship.[3] Thus, the question of maximizing gain by changing director size deserves a second look without the constraint of a fixed physical relationship between director lengths.

The purpose of this article is to examine Yagi gain performance under certain constraints:

- Maximum boom length will be limited to one wavelength, which is about the longest practical boom on 15, 20 or 40 meters.
- Antennas will be optimized for maximum gain. By concentrating on antenna gain, front-to-back ratio and bandwidth are not considered. While both are important, both generally take away from forward gain. Our primary focus is: what is the maximum Yagi gain for a given boom length, and how much better is the optimized gain from where we started?

procedure

Antennas will be modeled in free space using the assumptions presented in the **appendix**. The basic antenna design is initially estimated using the general principles outlined in the ARRL's *Antenna Handbook*, with equal spacing between the elements. Initial parameters are:

- Element diameter: 0.001 wavelength (1 inch on 20 meters)
- Reflector length: 0.51 wavelength
- Director lengths: 0.45 wavelength

The reflector's length will be increased by 0.0025 wavelength; the gain will again be calculated. If the forward gain improves by more than 0.01 dB, then that element will be incremented again in the same direction. If forward gain does not improve, the element will be shortened until the gain starts falling off. Once the reflector is optimized for forward gain, the same procedure is applied to the directors in order, and then back to the reflector. This iteration is continued until no further gain improvement is noted for a complete cycle through all parasitic elements. Once the antenna is optimized for forward gain using element perturbation, this same procedure is applied for element spacings with the first and last element fixed at the ends of the boom. Table 1 presents the starting and final values after forward gain optimization for some representative examples. After optimizing an antenna with equal element spacing, the same procedure is done for some antennas with unequal spacing.

For a given boom length and element spacing, the element lengths were found to converge smoothly to the same final values and were *independent of starting lengths*. Element and boom lengths in the tables are presented in terms of wavelength, but for **figs.**

By Dave Donnelly, K2SS, 8 Alder Street, Lincoln Park, New Jersey 07035

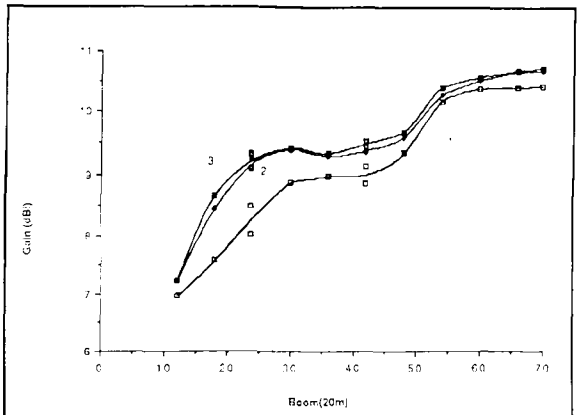


fig. 1. Forward gain against boom length (feet) for different 20 meter antennas. Line 1, open squares, are the original antennas; line 2, filled sqares, is following forward gain optimization by perturbation of element lengths; line 3, filled triangles, is following element and spacing perturbation. Note area of relatively flat gain between boom lengths of 24 and 50 feet.

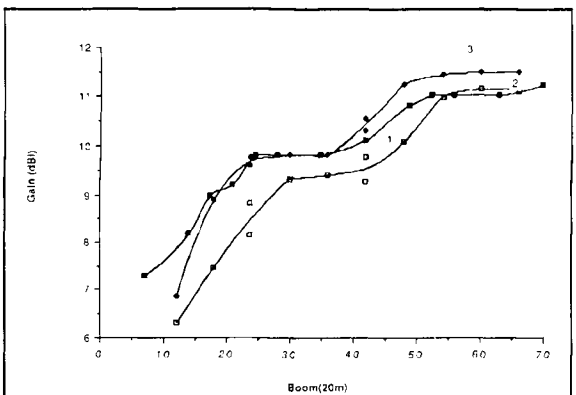


fig. 2. Forward gain against boom length (feet) for different 20 meter antennas using different computer models. Line 1, open squares, are the original antennas modeled with MININEC (20 match points per element, see Appendix for details); line 2, filled squares, is the peak forward gain data from Lawson[7,8] for each boom length; line 3, filled triangles, is optimized forward gain antennas using MININEC.

1 and **2**, the boom length is translated to a 20-meter antenna in order to provide a clearer sense of physical size.

results

Two- and three-element antennas on a short boom (0.17 and 0.258 wavelength, 12 and 18 feet on 20 meters) showed 6.8- to 6.9-dBi gain in the initial configuration that increased to 7.2 to 8.6 with optimization. A gain increase of 0.15 dB over equal spacing was found with close spacing of the driven-reflector in the three element configuration. On longer booms (.34, .43, .52, .60 and .68 wavelength, 24, 30, 36, 42 and 48 feet on 20 meters), configurations had between 8.0-9.1 dBi forward gain before and 9.1-9.6 dBi after optimization. A 4 element configuration on a .34 wavelength boom was about 0.2 dB better than a 3 element configuration.

Large antennas on booms of 0.77, 0.86, 0.95 and 1.0 wavelength (54, 60, 66 and 72 feet on 20 meters) had 10.1-10.5 dBi. Following optimization these antennas had 10.5-10.8 dBi.

Overall, the improvement in forward gain from the starting values was 0.7 (range: 0.3 to 1.53) dB, averaged over all the antennas, and usually came at the expense of front-to-back discrimination. In no case did the optimized antenna show any particular pattern in director taper — i.e., all elements getting shorter or longer.

Once an antenna is optimized for forward gain using element perturbation, changing the element spacing resulted in only minor forward gain improvement. The only exception was with wide spaced antennas (i.e. > 0.2 wavelengths) which work better with shorter element spacing between the reflector and driven elements.

In general, gain optimized antennas had reflectors which were rather short (about 0.49 wavelength or +j 30 ohms) and at least one director which was rather long (0.45-0.46 wavelength or −j 10 ohms). Since some parasitic elements are close to resonance, the optimized antennas would likely have a very limited bandwidth, and not adequately cover the CW and phone portions of the bands.

For a given boom length, the maximum gain figure was independent of the number of elements or spacing, with a slight edge to antennas with a short spacing from driven element to reflector (about 0.2 dB). Of particular interest is the relationship between maximum forward gain and boom length (**fig. 1**). The curve is not smooth, and shows a pronounced plateau after the 24-foot boom on 20 meters (0.35 wavelength) before again increasing with a 48-54-foot (0.76 wavelength) boom.

discussion

These results suggest two conclusions:

- Yagi antenna gain is basically only a function of boom length. However, the increase in gain is not smooth for boom lengths between 24 and 70 feet on 20 meters. Increasing the boom length from 24 to 48 feet increases the maximum gain by only 0.5 dB, while

Table 1. Element length and spacing, forward gain and front-to-back ratio (at the end of the horizon) for two-eight elements with boom lengths between 0.172 to 1 wavelength (12 and 70 feet, respectively, on 20 meters). Row *S* shows the starting element length (wavelength) with a diameter of 0.0005 wavelength. The position of the element from the reflector end of the boom is given in parenthesis. *R* is the reflector, *De* is the driven element, *D1* – *D6* are the first through sixth directors.

element length (boom position)

	R	De	D1 D4	D2 D5	D3 D6	gain (dB)	F/B (dB)
S	0.510(0)	0.470(0.17)				6.87	9.9
O	0.490(0)	0.470(0.17)				7.23	7.2
S	0.500(0)	0.470(0.17)	0.450(0.35)			8.07	34.7
O	0.492(0)	0.479(0.15)	0.482(0.35)			9.11	4.6
S	0.500(0)	0.470(0.11)	0.450(0.22)	0.450(0.35)		8.43	16.9
O	0.495(0)	0.470(0.10)	0.442(0.25)	0.477(0.35)		9.32	5.5
S	0.500(0)	0.470(0.17)	0.450(0.34)	0.450(0.53)		8.96	10.0
O	0.490(0)	0.470(0.15)	0.447(0.36)	0.460(0.52)		9.35	6.3
S	0.500(0)	0.470(0.15)	0.450(0.30)	0.450(0.45)	0.450(0.60)	9.12	10.1
O	0.490(0)	0.470(0.15)	0.445(0.32)	0.472(0.44)	0.440(0.60)	9.42	8.5
S	0.500(0)	0.470(0.17)	0.450(0.35)	0.450(0.52)	0.450(0.69)		
			0.450(0.86)			10.31	11.2
O	0.492(0)	0.470(0.15)	0.427(0.34)	0.455(0.53)	0.445(0.69)		
			0.455(0.86)			10.5	9.8
S	0.500(0)	0.470(0.15)	0.450(0.30)	0.450(0.44)	0.450(0.59)		
			0.450(0.74)	0.450(0.88)	0.450(1.03)	10.67	10
O	0.517(0)	0.470(0.15)	0.467(0.30)	0.447(0.44)	0.428(0.59)		
			0.443(0.74)	0.435(0.88)	0.447(1.03)	10.97	13

increasing the boom length by another 12 feet (to 60 feet) offers a 1-dB improvement.

•If one starts with reasonable element lengths, the average improvement in gain that can be expected is about 0.7 dB.

In other papers, Yagi gain was generally considered to be a smooth function of boom length. Bill Myers fit the NBS test range results to a curve and found good agreement for the function: Gain (dB) = 3 ln (boom length) + 12 dBi.[1] However, this was fit with data from boom lengths of 0.4 to 4.2 wavelength, and only two points at one wavelength or less. An examination of the calculated gains from a previous article suggests a conclusion similar to the one drawn here (**fig. 2**, line 2). A datum point for this figure was the peak gain numbers from all of the frequency points and all the element configurations for a given boom length presented in references 8 and 9. Keep in mind that these were *not* gain optimized antennas. Here again, forward gain was not a smooth function of boom length, but also showed a plateau region above 0.3 wavelength (24-foot boom on 20 meters). Although the plateau points don't correspond exactly to the lengths found in this paper, the phenomenon of nearly doubling boom length for 0.5 dB or less increase in gain is visible.

If one accepts this staircase phenomenon in forward gain, one would conclude that the ideal place to sit is at the edge of the step. From the computer results presented here, a good choice would be an optimally tuned four-element Yagi on a 24-foot boom for 20 meters. If you go to the effort of doubling the boom length to 48 feet, which probably requires a larger rotor, the forward gain may stay within 0.5 dB of the original antenna. Even if the boom length is expanded to 60 feet, the gain increase may only be 1.5 dB over the initial antenna. Is it worth the worry when the wind picks up?

The rather small average difference in forward gain between the initial and optimized antennas is surprising. The comments of Jim Lawson, W2PV, seem to be accurate and in order: "Yagi antennas 'want' to work."[5] The gain of non-optimized antennas is usually within 1 dB or so of the maximum possible gain. This frees the designer to optimize for other factors such as pattern nulls or average front-to-back without major worry that the forward gain will be compromised. Furthermore, one should not expect great increases in forward gain through fine tuning of the antenna. This may limit motivation for running up and down the tower, and performing hundreds of "This is antenna one, this is antenna two. . ." tests. Similarly, there is no magic about any particular antenna configuration. Thus, a 20 meter Yagi on a 24 foot boom should work the same (within a dB) whether it is homemade or from a commercial manufacturer.

In attempting to build actual antennas from data such as these, several factors must be kept in mind.

Although computer folks, myself included, tend to express gain to the hundredth[7] or thousandth dB,[2] the simplifying assumptions probably invalidate such accuracy. For instance, other investigators have assumed a real value for the self-impedance of 73 ohms,[2,6] while in reality, self-impedance varies between 50 and 100 ohms, depending on element length and diameter. Therefore, some of the terms in the impedance matrix are perhaps 20 percent in error. And an assumption that mutual impedance (coupling) between elements is independent of element length is probably only 90 percent accurate—shorter elements are less coupled. Nevertheless, despite these assumptions, the computer results show good correspondence to test range results,[7] and many fine working antennas have been based on computer designs.[11] A critical factor to keep in mind in implementing computer design data is constructing the same type element that was modeled; this is affected not only by element length, but also element diameter and physical taper. Two other papers provide an excellent discussion of this point.[10,11]

conclusion

Short antennas (with a 0.35-wavelength boom) can work very well, and it may not be cost effective to increase the boom size unless one goes almost two and a half to three times longer. Changing element lengths or element positions may provide a gain increase of about 1 dB.

appendix

This appendix provides the assumptions used for modeling the Yagi antennas, including how the mutual impedance matrix and gain were calculated. A more complete description of the general methodology is given elsewhere.[6]

The following assumptions and methodology were employed:

1. The mutual impedance between elements is assumed to be independent of element length and to be equal to published values for half-wave elements. This assumption was also used by others [2,6] and obviates the need to calculate mutual impedance for each antenna configuration, thereby greatly reducing computational time.

2. The self-impedance of an element is computed using Tai's formula, which estimates the real and imaginary self-impedance terms based on element length and element diameter:[4]

$$Z\ (\text{self}) = [122.65 - 204.1\ (k\ell) + 110\ (k\ell)^2]$$
$$-j\ 120\ [\ell n\ (\frac{2\ell}{a} - 1)\ \cot\ (k\ell) - 162.5 + 140\ (k\ell) - 40\ (k\ell)^2]$$

where ℓ is the element length, $k\ell$ is 2 pi/wavelength, and a is the diameter.

3. The impedance matrix is inverted and multiplied by the driving voltage matrix to give the element current distribution. The element currents are multiplied by the array factor for dipole elements to give the E field at a given value of theta and phi (spherical coordinates). The total radiated field is calculated by integrating theta and phi over a sphere and the gain in any direction is computed as the field ratio of the power in that direction divided by the average power flowing through the sphere. While this is theoretically equivalent to calculating the power in the forward direction and comparing to the input power at the driven element,[2,6] it is probably more accurate, since it is independent of uncertainties in driving impedance.

4. Because all calculations are done in free space, ground effects are neglected. The assumption is that the effect of the ground, which is to reinforce or cancel the radiated field, does not play a significant role in determining the current distribution.

Some reviewers of this manuscript were incredulous about the conclusion that forward gain did not increase smoothly with boom length and suggested that perhaps my underlying assumptions biased the results. Subsequently, I have performed the same optimization procedure using a version of MININEC with 20 match points per element. MININEC calculates all self and mutual impedances between element segments and thus does not use some of the assumptions I presented. Although the optimized element lengths were somewhat different than what I showed in **table 1**, the relationship of boom length to forward gain and the amount of improvement noted with gain optimization was identical. (See **fig. 2**, lines 1, 3.)

references

1. *Antenna Handbook*, ARRL, Newington, Connecticut, 1980, page 153.
2. Stan Jaffin, WB3GTU, "Applied Yagi Antenna Design, Part 1: A 2-Meter Classic Revisited," *ham radio*, May 1984, pages 14-28.
3. C. Chen, "Perturbation Techniques for Directivity Optimization of Yagi-Uda Arrays," Ph.D. Thesis, Syracuse University, 1974.
4. R. S. Elliot, in: *Antenna Theory and Design*, edited by R.S. Elliot, Prentice Hall, Englewood Cliffs, New Jersey, 1981, pages 301-303.
5. J. L. Lawson, W2PV, "Yagi Antenna Design: Optimizing Performance," *ham radio*, July 1980, pages 18-31.
6. J. L. Lawson, W2PV, "Yagi Antenna Design: Performance Calculations," *ham radio*, January 1980, pages 22-27.
7. J. L. Lawson, W2PV, "Yagi Antenna Design: Experiments Confirm Computer Analysis," *ham radio*, February 1980, pages 19-27.
8. J. L. Lawson, W2PV, "Yagi Antenna Design: Performance of Multielement Simplistic Beams," *ham radio*, May 1980, pages 18-32.
9. J. L. Lawson, W2PV, "Yagi Antenna Design: More Data on the Performance of Multi element Simplistic Beams," *ham radio*, June 1980, pages 33-40.
10. J. L. Lawson, W2PV, "Yagi Antenna Design: Practical Designs," *ham radio*, December 1980, pages 30-41.
11. Bill Myers, K1GQ, "The W2PV Four-element Yagi," *QST*, October, 1986, pages 15-19.

ham radio

homebrewing equipment
from parts to metal work

Helpful hints to get you started

Why are so few hams building electronic gear these days? To find out I conducted a survey among my ham friends. Three major reasons are:

- Lack of parts and difficulty in finding the necessary materials at reasonable prices.
- Choosing the wrong projects. Some pick projects of no use to their ham operations or that are too difficult for them to complete.
- The challenge of metal work can be overwhelming.

the parts problem

Inexpensive parts are readily available from many sources. Here are some possibilities:

- Local radio clubs often hold sales and auctions. Large, heavy World War II equipment (often called boat anchors) usually sells at give-away prices. Strip down for usable parts and hardware. Keep all screws, nuts, spacers, and small parts such as capacitors and resistors. Your junk box will soon overflow with building material.
- Garage and silent-key sales often yield worthwhile items. Look for wire, solder, tools, coax fittings, connectors, etc. If you don't have an immediate need, buy parts and store them for future use.
- Hamfests. Watch for notices in ham publications. The flea market is usually the main attraction; the variety of material is unbelievable. Where else can you buy a Weston meter for a buck? Testing your bargaining skills is fun.
- Electronic surplus houses. These are scattered across the country, and frequently advertise in the yellow pages of the local phone book. Better companies often publish catalogs.
- Junk yards. Some of my best buys were made at junk yards where electronic material occasionally shows up as a byproduct and the seller doesn't know its value. I recently purchased some excellent coaxial cable at ten cents a foot.
- Ham friends. Some of your acquaintances may have a basement, garage, or an attic full of items collected in the heyday of World War II surplus sales.
- On-the-air swap meets can be an excellent source of cheap parts. I have contacted many hams on the air to buy hard-to-get items. You must be flexible in your selection; sensible substitutions come from experience.

selecting the right project

Keep your first project simple. It's easy to get discouraged if your initial attempt is too difficult. As you finish one project, look for something more complicated to test your abilities. I started building items such as field strength meters, moved on to antenna tuners, and finally to a linear amplifier. Build an item you will use in your ham operations. You'll give your confidence a boost if you build something and use it.

preliminary design

The foundation of any electronic project is the panel, chassis and, cabinet. Do your homework on circuit design and determine its size before gathering materials.

When you have all the necessary parts, decide on their proper placement. Look at handbook illustrations and photos to see how the experts do it. Juggle the parts into a configuration that meets your project's requirements. For example, short rf leads are important. Keep the coils spaced from metal shields by a distance at least one half their (coil) diameter. The rf switches must be close to the coils to maintain short lead length. Allow plenty of space around high-voltage components to avoid flashovers.

Don't design in layers that will be hard to wire initially; it may be difficult to repair or replace components later.

metal fabrication

Most hams dislike metal work either because they don't have the proper tools or don't know how to use them. This situation has an easy solution.

Cabinet and chassis dimensions are determined when your design and parts placement are frozen. Now start looking for sources of sheet aluminum. It's the only material easily worked and electrically excellent. I find aluminum at salvage yards, surplus houses, and flea markets. Prices average $1.25 per pound. Buy 6061T-6 alloy for panels or pieces that don't need bending. Material 1/8 inch thick is needed; it's stiff and machines cleanly. Choose bendable material for the chassis and outer cabinet. Test for flexibility by bending a small corner with a pair of pliers. It should

By Paul A. Johnson, W7KBE, 10817 Brookside Drive, Sun City, Arizona 85351

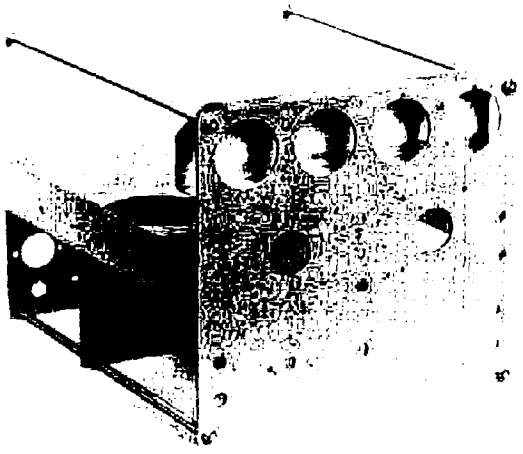


fig. 1. RF deck for KW linear amplifier. There's ample room in this compact 11" x 16" homebrew chassis for excellent parts placement and ease of wiring from all angles.

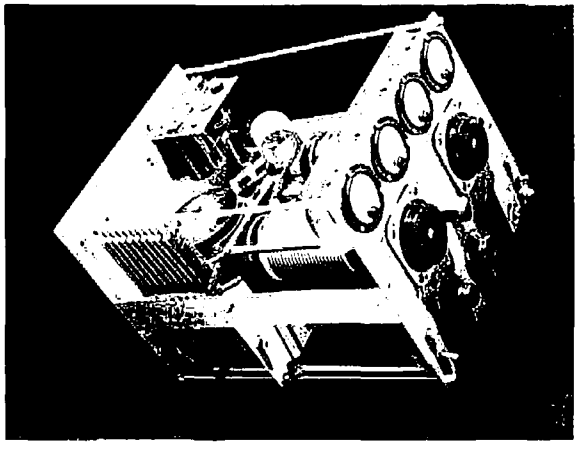


fig. 2. The wiring has been completed and tested on this amplifier that covers all the bands using two roller inductors and a variable vacuum capacitor in a Pi L network.

bend 90 degrees without breaking or springing back. Use 1/16 inch aluminum for these parts.

When looking for sheet aluminum, remember that salvage yards buy and sell *drops* (random sized pieces left from manufacturing processes). You can usually find material close to the correct size. One word of caution: stay away from aluminum that has been exposed to the weather -- it's hard to clean.

tools to use

You can cut aluminum easily with hack, sabre, circular, and hole saws or with a fly cutter. Cut meter holes with a hole saw or fly cutter (which must be used in a drill press at its lowest speed). Fly cutters can be dangerous; use cutting lubricants like kerosene or paraffin and smooth ragged edges with a file. Clamp the panel to the table, cut halfway through, then turn the panel over to finish the job. Greenlee punches are useful for making holes ranging from 1/2 to 1-1/2 inches in diameter.

Aluminum angle, 1/4-inch threaded rod and nuts, 6-32 machine screws and nuts, and no. 6 drive screws are needed and can be found at well-stocked hardware stores.

bending aluminum

You'll need to bend the aluminum for the chassis and cabinets, something that's difficult to do with regular home tools. Take the pieces that need bending to a local sheet metal shop. Let the metal worker figure the dimensions as he knows the allowances that have to be made for proper fitting. Sometimes you can avoid making bends by using angle aluminum.

the finished product

Figure 1 shows the skeleton frame of an assembly designed to house a linear amplifier. Note the simple construction. The front and back panels are the same size, and held together with four 1/4-inch threaded rods. To assure perfect alignment between front and back panels, clamp them together and drill holes for the 1/4-inch threaded rod through both. The meter shield has only one 90 degree bend. The side rails, chassis, and outer shell covers all have two bends. With the outer shell in place, all the necessary shielding is complete.

The chassis is open for ease of assembly. When all parts are in place, wiring is easy. Nothing is buried. Coils, switches, and capacitors are placed for efficient operation at radio frequencies. **Figure 2** shows that there is no layering of parts. This makes future repairs, changes, or parts replacement easy.

Figure 3 shows a completed 1-kW linear amplifier. The outer shell is held to the side rails with no. 6 sheet metal screws. The front of the cabinet extends beyond the front panel to give a shadow box effect similar to many commercial cabinets.

This open frame construction can be still be used if you find a commercial cabinet that fits your needs. **Figure 4** shows an antenna tuner for 40, 80, and 160 meters designed for open wire line. The sliding switch[1] and the coils[2] are homemade. The assembly in **fig. 4** was easy to wire and slides into a commercial cabinet.

finishing the metal work

After drilling the holes, assemble the pieces to make sure everything fits. Now disassemble and clean each surface with sandpaper (100 grit). Remove all burrs and scrub down the metal with an abrasive cleanser; now you're ready to paint. I paint only the front panel and outer shell; try making the panel one color and the outer shell another as contrasting colors enhance

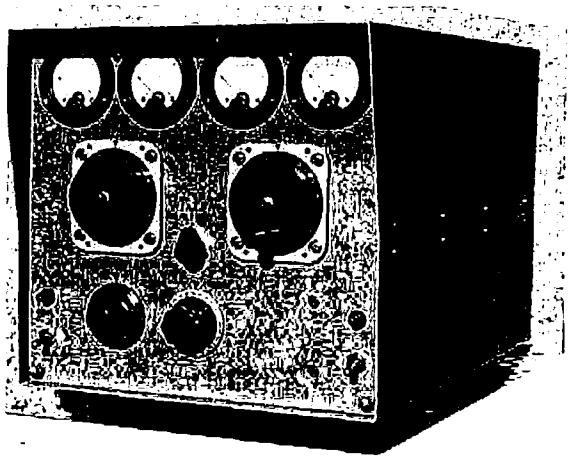


fig. 3. Here's the amplifier buttoned up and ready for action. Plenty of meters are available to monitor all circuitry. A symetrical layout of the front panel adds to the appearance. Notice the use of surplus dial counters and meters.

the appearance. Epoxy metal spray paint does a good job.

the final touch

Reassemble and wire all components. You need to maintain excellent contact between parts and sheet metal. Don't skimp on the number of screws; rf grounds are very important.

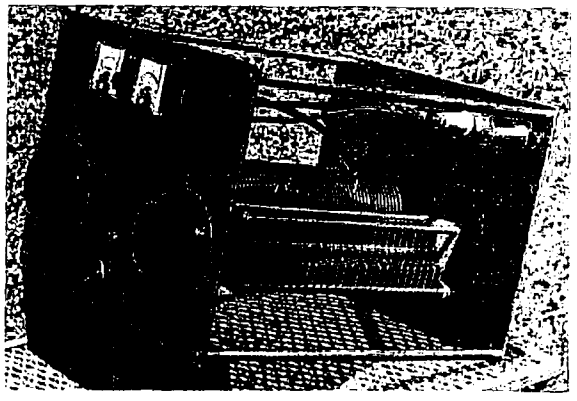


fig. 4. This tuner was housed in a commercial cabinet which had a hinged top cover to allow ready access to the tapped coil. The meters display POWER and VSWR.

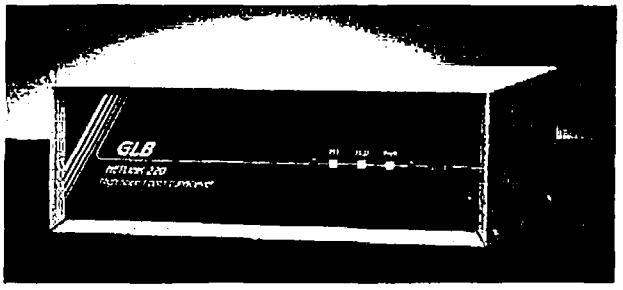
I have built many of these cabinets for my friends and myself. The designs evolved over years of trying to simplify construction of homebrewed equipment. I think the finished product is very functional. Why not give it a try?

1. Johnson, Paul A., "Be Switched, Easily," *QST*, February 1983, page 18.
2. Johnson, Paul A., "Constructing Air-wound Coils," *ham radio*, August 1984, page 37.

ham radio

NEW FROM GLB

GLB NETLINK 220
HIGH-SPEED DATA TRANSCEIVER



FEATURES

SPECIFICATIONS

See us at DAYTON Booth 310

Amateur net $ 699.95
List price $ 799.95

GLB ELECTRONICS, INC. 151 Commerce Pkwy., Buffalo, NY 14224 716-675-6740 9 to 4

230

INTERNATIONAL MONTHLY MAGAZINE BY AND FOR ACTIVE RADIOAMATEURS

Radiosporting

THIS IS IT! – FOR BIG GUNS & LITTLE PISTOLS

A magazine dedicated to quality and sportsmanship in amateur radio operating. Fresh, timely, practical and down to earth reading for little pistols and big guns. Written by the world's best in their fields: ON4UN, SMØAGD, LZ2CJ, VE3BMV, KH6BZF, DJ9ZB, ZS6BRZ, W1WY, N2AU, K7GCO, K4ZN, W4GF, VE3JTQ, WB4ZNH, WB9TBU, KQ2M, NS6X, W3FG, KA3B, K1PLR, N7CKD, VE3XN, ABØX, JE1CKA and others.

Includes DX News, QSL Info, 160m, 80m, 10m, 6m columns, DXpeditioning, Propagation, Awards, Contest rules and results, Traffic – Emergency, FCC News, New Products, Antennas, Technical news and articles, equipment reviews and modifications, computer programs, Radio Funnies, Club Life, RTTY, VHF/UHF, Mail Box, Classified Ads and much more in a magazine format with the speed of a bulletin.

RADIOSPORTING sponsors DX Century Award, Contest Hall of Fame and World Radio Championship contest.

"Your publication is superb! Keep it up!" Joe Reisert, W1JR

"Your W2PV articles are priceless. Your magazine is super!" Rush Drake, W7RM

"Let me congratulate you on a very impressive magazine. Just what I've been looking for as a DXer and Contester!" Dick Moen, N7RO

"RADIOSPORTING, once received, cannot be tossed aside until it is read from cover to cover. Then reviewed again and again." Chas Browning, W4PKA

Subscription rates: 1 year USA $18, Canada CDN$26, Overseas US$23; 2 years $33, $48, $42 respectively. Single issue $2. USA First Class Mail add $8/year, DX Air Mail add $15/year.

TRY US! SUBSCRIBE OR SEND $1 FOR YOUR SAMPLE COPY.
RADIOSPORTING Magazine
PO Box 282, Pine Brook, NJ 07058, USA

229

automatically switched half-octave filters: part 2

Modular approach facilitates construction, improves performance

In part one,* we discussed the low-pass and bandpass requirements for multi-octave transmitters and receivers. They differ considerably from the ones needed for narrowband applications like those in Amateur equipment with 500-kHz band coverage. We found that the best way to use filters in a multi-octave transmitter application with stringent attenuation and ripple characteristics is to select contiguous half-octave networks that will attenuate second-order and higher harmonic products while maintaining flat bandpass characteristics (**fig. 1**).

We discussed the practical limitations of filter design and the tradeoffs in linear amplifier design necessary to reduce the complexity of the filters, presented an ideal filter model, and discussed how some practical filter approximations can satisfy stringent requirements better than others. Based on this knowledge, we selected the Cauer (elliptical) filter for our application, and designed bandpass and low-pass networks for a full coverage transceiver. In part 2, we will implement the low-pass filters from **table 3** of part 1 in the transceiver environment. This requires additional design in the areas of rf switching and digital decoding that will have to work with the filter networks, the control system of the transceiver, and the mechanical design.

system implementation

Because the low-pass networks must withstand high power (and high VSWR), they need to be implemented with relatively large inductors and capacitors, which will take up space in the compact transceiver.

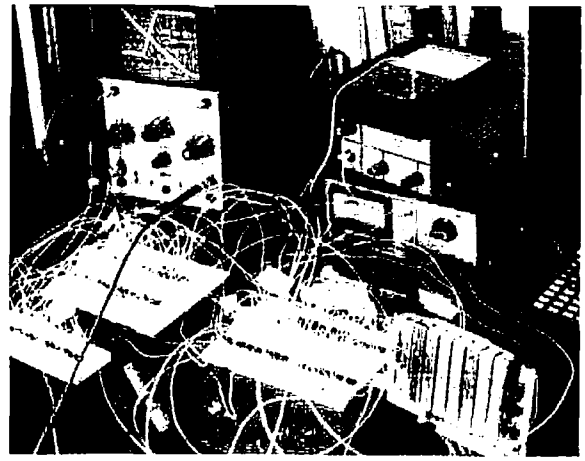


fig. 1. Breadboarding the automatic filters for the WB3JZO transceiver.

By contrast, the modular packaging of the transceiver dictates the use of small pc boards containing sensitive driving circuits and arrays of rf power relays for switching in the proper networks at the right time. This combination of rf and digital circuits could be cumbersome if not properly designed and implemented, even though we planned the networks with a minimum number of poles.

A special approach to packaging was adopted in the WB3JZO transceiver. To keep the digital circuits away from the rf, the filter networks are packaged in separate plug-in assemblies, each containing four filters (**fig. 2A**). The assemblies plug into pc boards containing all the digital circuitry and switching. Stainless steel containers were constructed with Teflon™ standoffs to give mechanical support to the inductors and capacitors. In addition, a set of precision-guided RCA connectors were built into the containers for quick connect/disconnect of all filters from the pc boards.

This construction proved effective in preventing the

By Cornell Drentea, WB3JZO 7140 Colorado Avenue North, Minneapolis, Minnesota 55429 and **Lee R Watkins**, 2256 East Jaeger Street, Mesa, Arizona 85213.

*Cornell Drentea, WB3JZO, and Lee R Watkins, "Automatically Switched Half Octave Filters, part 1," *ham radio*, February 1988, pages 10-32.

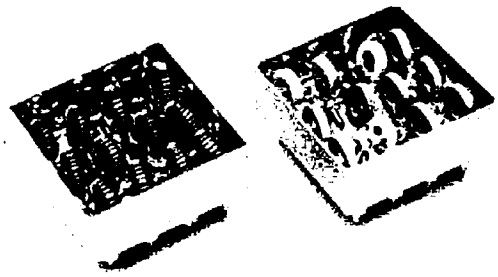


fig. 2A. Implementing the filter banks in the WB3JZO transceiver. Stainless steel containers with built-in Teflon™ standoffs and precision guided RCA connectors allow off-board access to the filters for tuning. This packaging keeps rf out of the digital circuits.

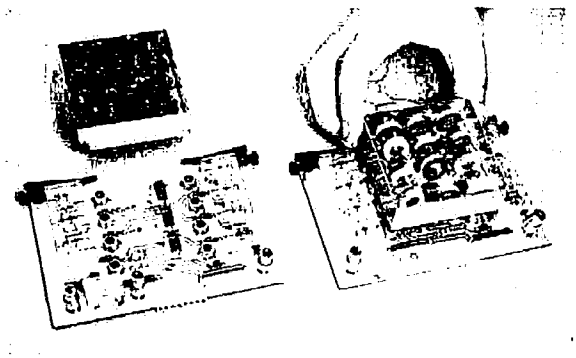


fig. 2B. Filter assemblies are easily inserted into the pc boards which in turn plug into the transceiver.

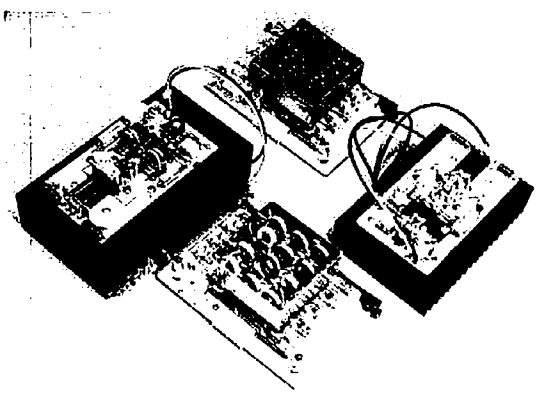


fig. 3. View of the amplifier assemblies and associated filter banks.

rf from getting into the sensitive digital circuitry on the pc boards under the filter assemblies. High-power rf switching relays, associated striplines, and rf connectors were built into the boards. The separate containers and pc boards allow independent rf tuning and digital testing of the networks and their switching. Each bank of filters can be plugged or unplugged from the pc boards (**fig. 2B**). Two board assemblies are required for the eight low-pass filters. Only one board is needed to accommodate the bandpass filter bank, since the size of the parts for these filters permits miniaturization.

Many other design goals were considered. An opto-encoded digital count up/down circuit on the digital interface command board (DBIC) at the front of the transceiver provides decoding for all filter banks, and works in conjunction with two other interface boards. The frequency word logic board (FWLB) lets the operator dial up any frequency from the transceiver's front panel and the frequency mode display board (FMDB) serves as digital display feedback. The high-gain (39 dB) linear amplifier chain and the low-pass filter banks are shown in **fig. 3**.

The system is implemented modularly and connected via ribbon cables and motherboard layout to decode and communicate information to the proper automatically selected filters. The rf paths are joined by RG-174/U and RG-58/U coaxial cables, depending on rf power requirements. Digital information is transmitted to the synthesizer as corrected by the i-f value and CW shift. Several other functions were incorporated: power-up memory for the "mode" mechanism, ensuring that the transceiver always starts up in upper sideband; alpha-numeric display circuits with electronic band edge stops at 2 and 30 MHz, to prevent operation outside the range; various sequencing and delay circuits that work in conjunction with the synthesizer; and AGC command functions, thumbwheel encoding circuits, and a multiple-tone alert system working in the receiver's audio section. **Figure 4A** shows all significant digital assemblies and the filter banks prior to final transceiver packaging; **figs. 4B** and **4C** show their incorporation in the transceiver.

building the filters

Next, we will see how the low-pass filters from **table 3** of part 1 were constructed. First, precision inductors were devised for all values from the table. We used commercial Micrometals™ T-68 toroid cores -- red mix No. 2 for the lower frequency banks and yellow mix No. 6 for the higher frequencies. The number of turns (N_2) was calculated using the equations listed in **table 1**. The final inductance adjustments were made with the setup shown in **fig. 5**.

By placing a precision silver mica capacitor of known value across each of the inductors and using a grid dip meter and digital frequency counter to measure the resonance of the circuit, the value of L was calculated with the equations shown in **table 2**. The counter measured the frequency of the grid dip meter's oscillator at the precise resonance point. The

Table 1. Equation used to calculate the number of turns (N_2).

$$\frac{L_1}{|N_1|^2} = \frac{L_2}{|N_2|^2} \quad \text{Eqn. 1}$$

$$L_1|N_2|^2 = L_2|N_1|^2 \quad \text{Eqn. 2}$$

$$|N_2|^2 = \frac{L_2|N_1|^2}{L_1} \quad \text{Eqn. 3}$$

$$N_2 = \sqrt{\frac{L_2|N_1|^2}{L_1}} \quad \text{Eqn. 4}$$

Where:

N_2 = Required number of turns
L_1 = Known inductance per 100 turns*
L_2 = Known required inductance
N_1 = 100

*Values of L_1 from tables

- T68-2 = 55 μH
- T68-6 = 47 μH

Table 2. Equation used to calculate the value of L.

$$L = \frac{25330}{(F^2\ C)} \quad \text{Eqn. 5} \qquad C = \frac{25330}{(F^2\ L)} \quad \text{Eqn. 6}$$

Example: If C = 107.6, L = 3.40 μH
To resonate at 8.316 MHz
(from filter no. 1, Table 3 (from part 1).

numbers were entered into a TI-59 calculator programmed to solve for L or C according to the equations. This semiautomated process allowed quick, consistent, error-free calculations, making measurements for all the inductors easy. The setup worked well for all cases. Adjustments were made to the coils by pushing or spreading the windings a bit. The same procedure was used to obtain practical combinations of capacitor values approaching the theoretical values prescribed in **table 3** of part 1. In this case, the equation was solved for C rather than L (**table 2**). The parts were then soldered into the containers, using RCA connectors and Teflon standoffs as mechanical supports. The filters were then tuned for theoretical peaks with a Collins R-392 receiver used as a spectrum analyzer. We later used an HP-8754 network analyzer to complete the job.

Figure 6 shows the composite frequency response of the finished low-pass filters as plotted with the

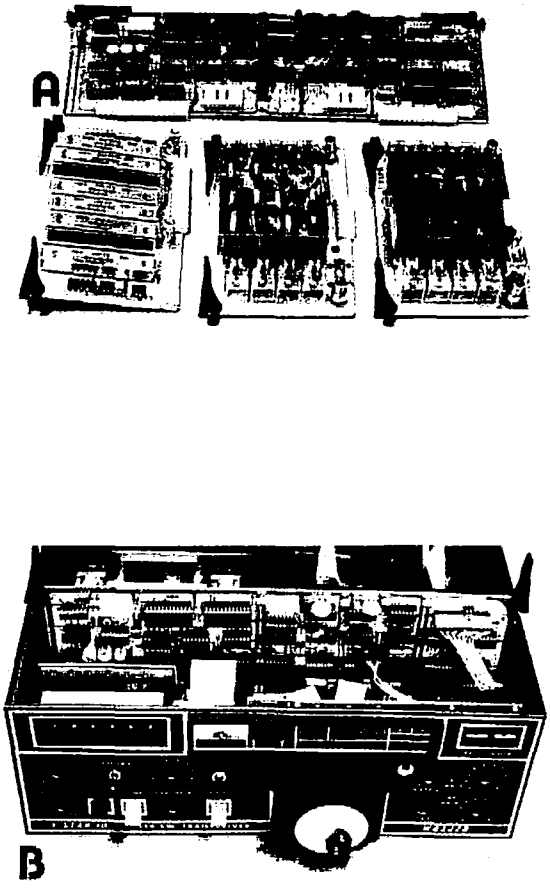


fig. 4. (A) View of significant assemblies associated with the implementation of the filters. Shown are all filter banks and the digital interface command board (DBIC). (B) and (C) Views of all digital boards and filter assemblies as packaged in the transceiver. In addition to the boards and visible behind the front panel are the frequency word logic board (FWLB) and the frequency mode display board (FMDB). All boards are interconnected via continuous ribbon cables equipped with press-on connectors.

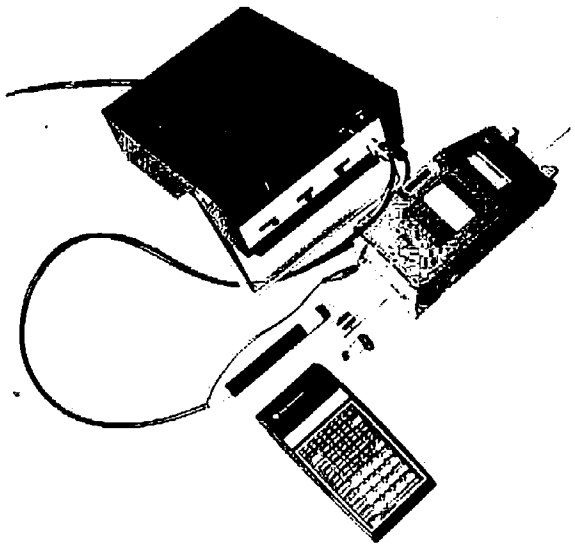


fig. 5. Setup used to speed up the inductance measurement process. The toroidal coil under test was paralleled by a known precision silver mica capacitor. The exact frequency of the circuit was read with a digital counter which measured the frequency of rf generated by the grid dip meter at resonance. All numbers were inputted to the TI-59 programmable calculator which resolved the equation for L or C.

analyzer. Little work was needed to bring the filters within the design specifications. We also performed spectrum analyzer tests (fig. 7).

communication and decoding mechanism

The schematic diagram of the low-pass assemblies, and their switching mechanism, are shown in fig. 8A. Figure 8B shows the implementation of the bandpass banks with their corresponding switching. Some of the functions included here are filter switching with associated driving circuits, transmit/receive (T/R) switching, and the transmitter gain control (TGC) sensory circuit. Next, we will discuss the communication and decoding mechanism.

We decided early in the design that digital communications in the transceiver would be performed with parallel low-true TTL levels for good noise immunity in the presence of an rf field. This meant that the TTL lines would be terminated on the destination boards with 75451 line drivers, normally used in computer communications hardware. These devices deliver up to 400 milliamperes of current at 5 volts and can drive relays directly. They have been used throughout the system, in the control circuits, as relay drivers for all filter boards, and as power switches for muting the receiver's i-f section. The 75451 is an integrated circuit containing two drivers and associated TTL logic. Two of these were used per filter board (fig. 8). Reverse-biased silicon diodes on the coils eliminated voltage transients that occur when current is interrupted.

The rf relays were standard parts chosen for their reliability and low cost (evidenced by their use in commercial maritime transceivers). Small Teledyne rf relays were used for the bandpass bank. The design lets only one filter be switched in at any given time, eliminating possible interaction between the selected filter and adjacent devices. During selection, all other filters are shorted to ground at the input and output; this is done by taking advantage of the natural resting position of

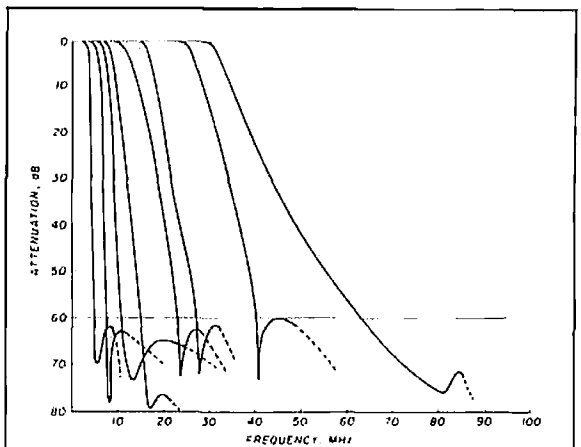


fig. 6. Actual frequency response plot of all the low-pass filters was obtained with the HP-8756 network analyzer. The response curves show compliance with design goal specifications from *table 1* (from part 1).

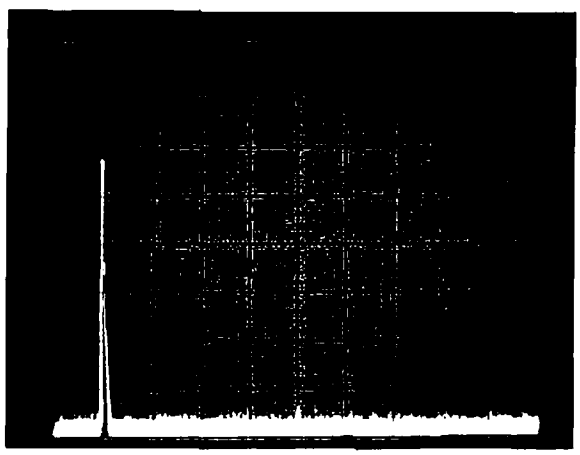
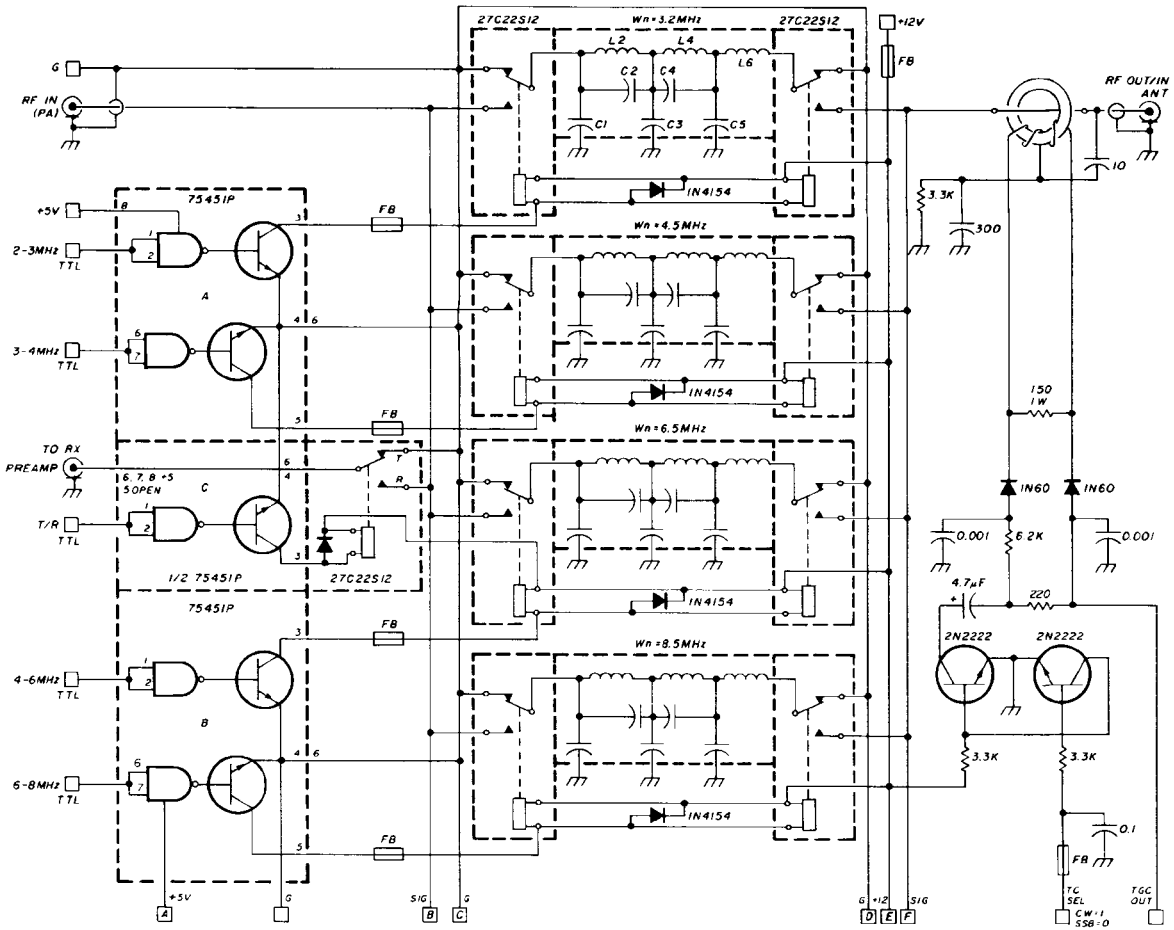


fig. 7. Typical worst-case spectrum analyzer test shows that harmonics are at least 50 dB below the carrier. Filter No. 4 was used in this example. Similar results are obtained with the other low-pass filters.


27C22S12
Wn=3.2MHz
27C22S12
+12V
FB
G
RF IN (PA)
L2
L4
L6
C2
C4
C1
C3
C5
RF OUT/IN ANT
10
1N4154
3.3K
300
75451P
+5V
2-3MHz TTL
3-4MHz TTL
A
Wn=4.5MHz
150 1W
TO RX PREAMP
6, 7, 8 =5 5 OPEN
T
R
C
T/R TTL
1N60
1N60
0.001
6.2K
0.001
4.7μF
220
1/2 75451P
27C22S12
75451P
2N2222
2N2222
Wn=6.5MHz
4-6MHz TTL
B
6-8MHz TTL
3.3K
3.3K
0.1
Wn=8.5MHz
TG SEL
CW=1 SSB=0
TGC OUT
+5V
G
SIG
G
G
+12
SIG
A
B
C
D
E
F

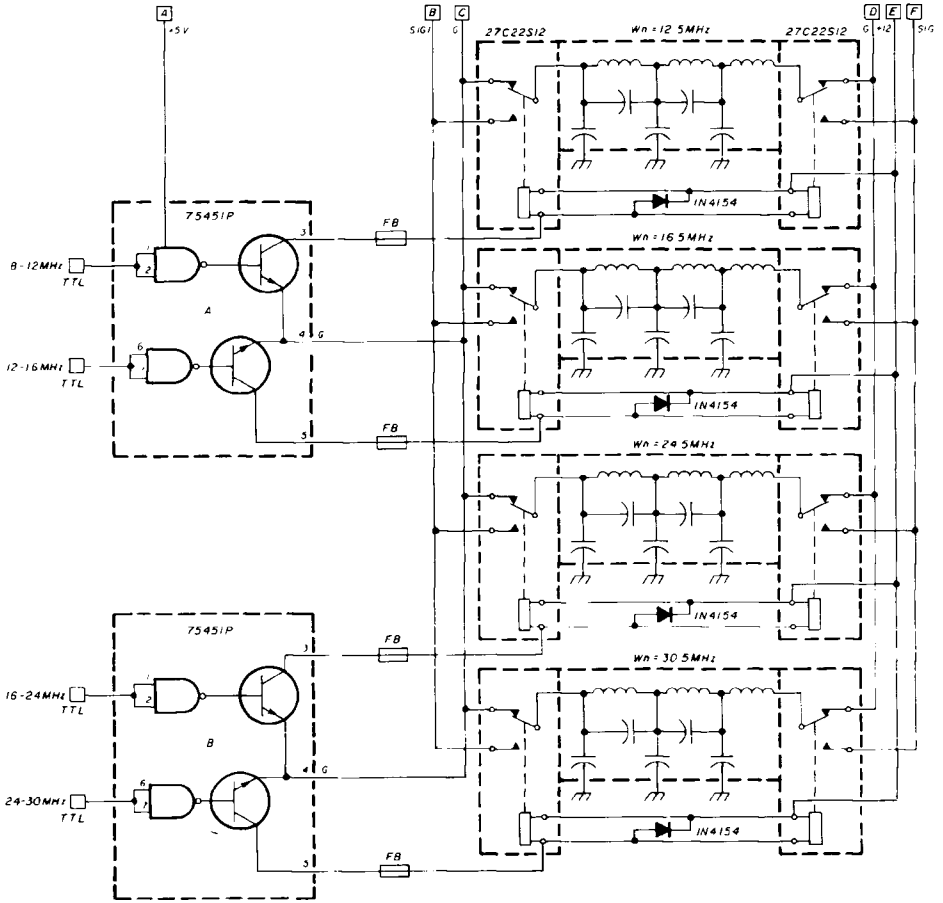


fig. 8A. Schematic diagram of the switching mechanism for the low-pass assemblies.

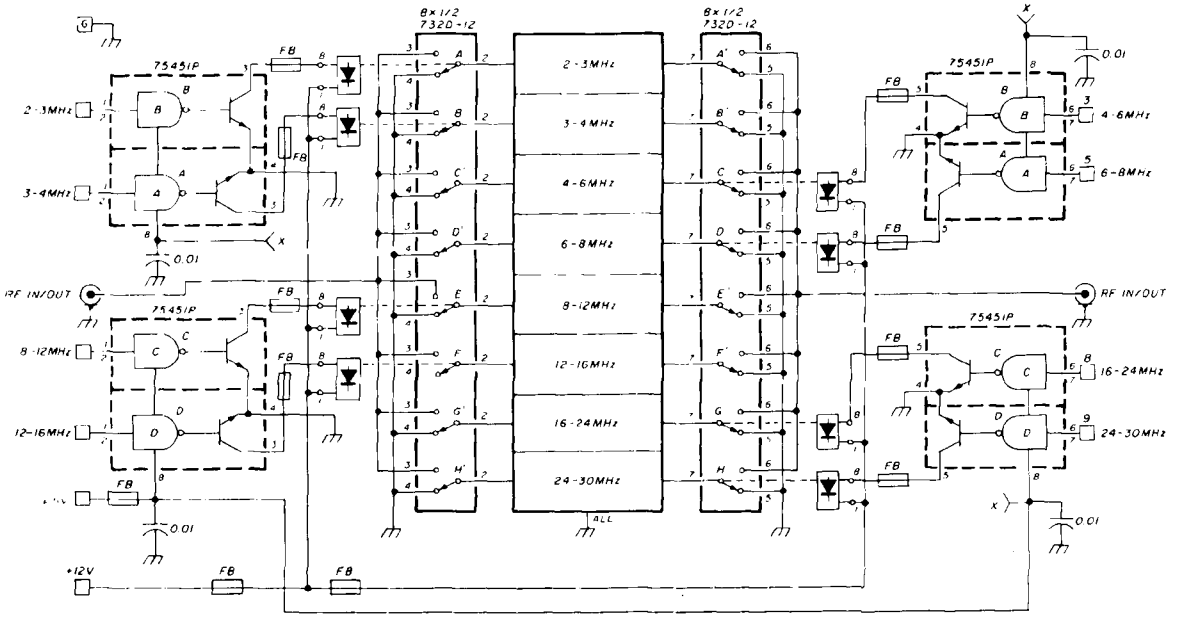


fig. 8B. Bandpass assembly.

the relay arms. We observed no stray effects between the active filter networks and adjacent coils, despite the compact packaging. Ferrite beads were used in all relay driving lines to prevent rf from getting into the dc switching circuits. Finally, all power lines were bypassed with decoupling capacitors and rf chokes and the finished product worked smoothly.

digital intelligence

The decoding for selecting the appropriate filter networks was designed into the digital interface command board (**fig. 9**). When power is first applied, all logic circuits are reset via the built-in power-on strobe circuits as shown. This mutes the receiver and transmitter circuits until the synthesizer locks up on the frequency indicated by the thumbwheel switch and the dot-matrix LED display. Within a few milliseconds a short tone burst, audible through the audio amplifier of the transceiver, signals transceiver readiness. The entire transceiver then is set to the frequency indicated by the thumbwheel switch, which also controls the filter selection. The half-octave filters are automatically selected by the BCD-to-decimal decoder, which in turn activates one of the eight lines going to the filter banks (**fig. 9**). In addition, parallel digital data intended for the display is modified by the amount of i-f frequency before being sent to the synthesizer.

final considerations

Some additional, but unrelated, circuits are shown in **fig. 9**. In the WB3JZO transceiver, mode selection is made automatically at power-up and is initially in the upper sideband condition. It is controlled with a push-push sequencer button located in the front of the transceiver. Selection is indicated by a large LED display, visible through the front panel, programmed to show the letters U, L, or variations of the letter C for different CW bandwidths. Similar circuits control the AGC characteristics of the receiver, and several other functions. The frequency display shows the frequency of the thumbwheel switch (which acts as a 280,000-position band switch) as soon as power is applied. The operator can then take over the frequency control manually via the optical interrupter of the transceiver over a 10-kHz range. Split operation is activated by the memory switch (**fig. 9**).

When the operator sets the thumbwheel switch to the chosen frequency, the 7430 NAND gate IC detects any large frequency change and resets all circuits. This mutes the transceiver for a few milliseconds until there is lock-up and the MC-4024 generates a short sequence of tones indicating that the change has been made. Any out-of-band (i.e., outside the range of 2 to 30 MHz) condition disables transmitting and receiving circuits generating a set of aural and visual alarms (audio tones and all decimal points are lit on the alphanumeric display).

conclusion

This paper details a procedure for defining and

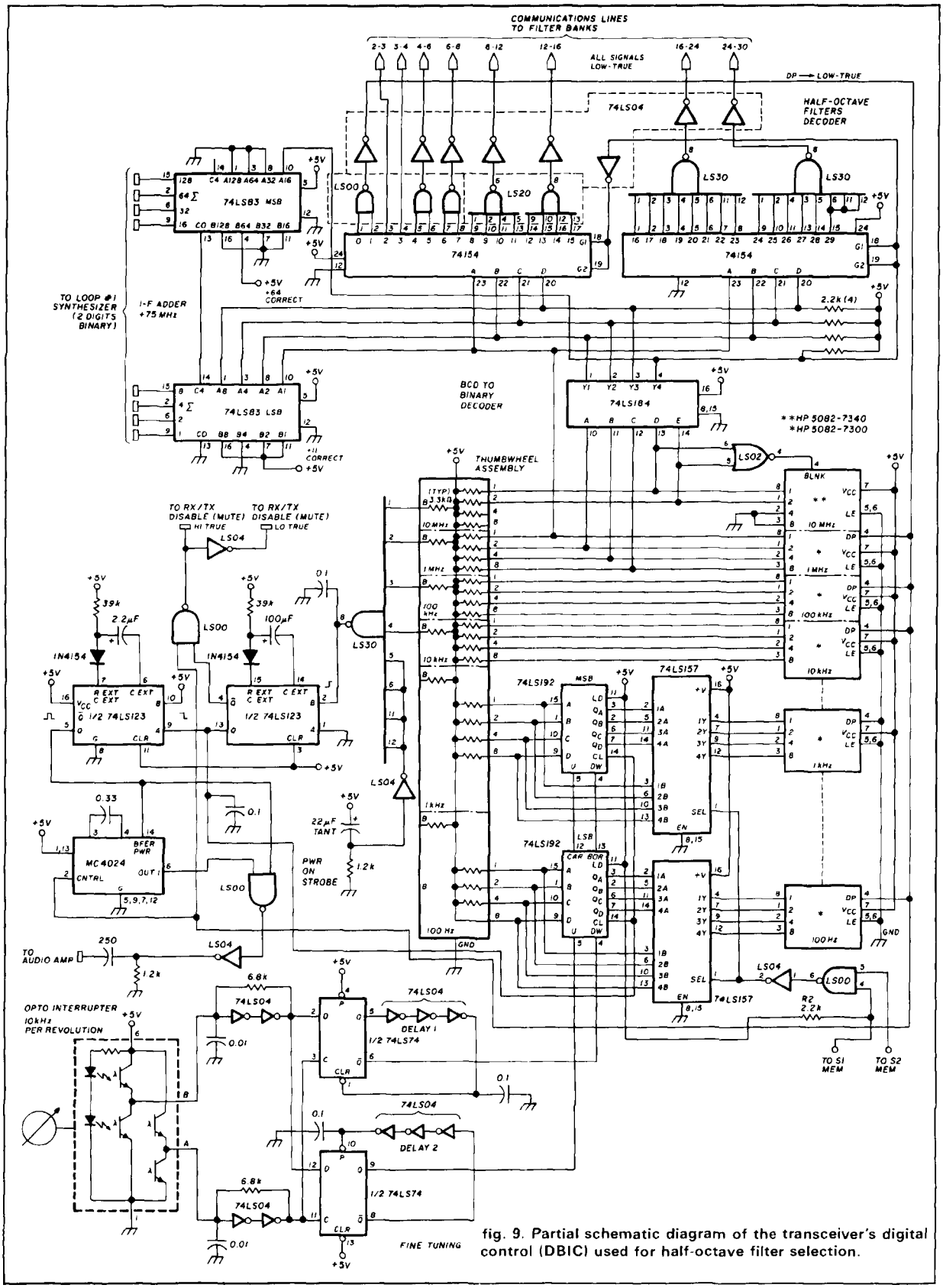


fig. 9. Partial schematic diagram of the transceiver's digital control (DBIC) used for half-octave filter selection.

implementing automatic switched half-octave filters. The key to this method is to design the electrical filters with a minimum number of elements, while maintaining stringent electrical and mechanical requirements over a wide frequency range.

The resulting architecture is modular in that it preserves the plug-in board approach in a high-power rf environment and allows for proper digital interfacing to automate the system.

Although this project is dedicated to hf communications and particularly to linear amplifier harmonic suppression, there are many opportunities for using similar systems in other signal processing tasks. The authors would like to hear from anyone who has found new or novel applications for this concept.

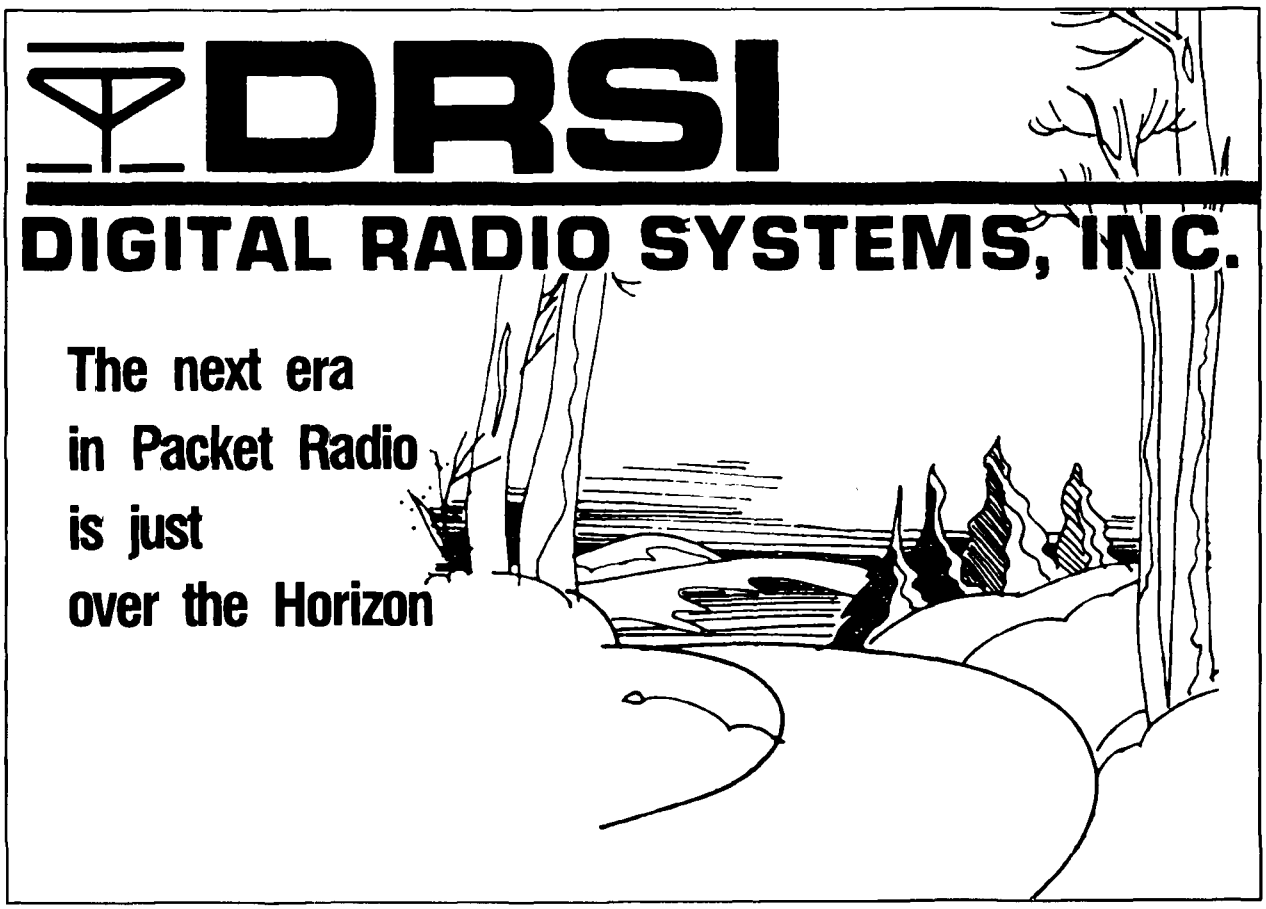
acknowledgments

We would like to acknowledge Gary Dublin, NØBAB, for his help in performing the network and spectrum analyzer tests needed for the development of the WB3JZO transceiver; and Mike Stapp, KAØTQY, and Marc Denis, KDØQO, for carefully reviewing the material.

bibliography

1. Anatol I. Zverev, *Handbook of Filter Synthesis*, Wiley, New York, 1967.
2. Herman J. Blinchikoff and Anatol I.Zverev, *Filtering in the Time and Frequency Domains*, Wiley, New York, 1976.
3. Lee R Watkins, "Designing Narrowband Butterworth or Chebyshev Filters in Less Than Two Minutes Using the TI-59 Calculator/Printer," *rf design*, November-December, 1980, pages 22-31.
4. Deverl S. Humphreys, *The Analysis, Design, and Synthesis of Electrical Filters*, Prentice-Hall, Englewood Cliffs, New Jersey, 1970.
5. Arthur C. Williams, *Electronic Filter Design Handbook*, McGraw-Hill, 1981.
6. Von R. Saal, *Der Entwurf von Filtern mit Hilfe des Kataloges Normierter Tiefpässe*, AEG-Telefunken, 715 Backnang, West Germany, 1968.
7. Von R. Saal and E. Ulbrich, "On the Design of Filters by Synthesis," *IRE Transactions on Circuit Theory*, December 1958.
8. Phillip R. Geffe, *Simplified Modern Filter Design*, John F. Rider Publishing, Inc., New York, 1963.
9. Lee R Watkins, "Wideband Filter Design Method Uses a Least-squares Approximation to Constant Group Delay," *Microwave Systems News*, October 1984, pages 141-144.
10. Donald D. Weiner and John E. Spina, *Sinusoidal Analysis and Modeling of Weakly Nonlinear Circuits with Applications to Nonlinear Interference Effects*, Van Nostrand Reinhold, New York, 1980.
11. Cornell Drentea, *Radio Communciations Receivers*, TAB Books, 1982.
12. Clare D. McGillem and George R. Cooper, *Continuous and Discrete Signal and System Analysis*, Purdue University Press, 1974.
13. *RF Data Manual*, Motorola, Inc., 1982.
14. *ARRL Electronics Data Book*, The American Radio Relay League, Newington, Connecticut 06111, 1976.

ham radio



frequency calibration
using 60 kHz WWVB

phase comparison method using NBS station yields higher accuracy

As the techniques used by the average Amateur Radio operator become more sophisticated, the need for precise frequency control becomes more important. Satellite communications, digital data links, coherent CW operation, and even the everyday business of saying "QSY to 14259.0" all place increasing demands on our ability to accurately measure frequency.

WWV and WWVH have been used for years to calibrate equipment by audibly comparing transmitted signals against the receiver's internal reference oscillator for zero beat. This is still the most convenient method. However, for greater calibration accuracy, use station WWVB which transmits on 60kHz.

WWVB broadcasts a highly stable reference signal in the Very Low Frequency (VLF) band and, despite its relatively low power, is receivable nationwide. Its signal is a continuous carrier modulated by decreasing output power 10 dB on the second for varying pulse widths. In this way, time, date, and error information are sent in binary format without disturbing the phase coherence of the reference signal. None of this information is decodable using standard audio detection techniques.

In recent years there have been a number of articles dealing with reception at VLF. Most employ conversion circuits which work fine for a-m, CW, and RTTY but are useless for reference work. The following circuit overcomes this limitation by using a synchronous detection scheme, which when used in conjunction with an oscilloscope, gives a convenient visual readout of frequency error.

The rf signal from the antenna is amplified without conversion using moderate selectivity and after conditioning is fed to the vertical channel of an oscilloscope. If the horizonal sweep time is then set to display about two cycles at 60 kHz (5 microseconds per cm on my scope), and the sweep is triggered by an oscillator at 60 kHz or any submultiple frequency (i.e. 60 kHz/n; where n = 1, 2, 3, etc.) the rf signal can be directly viewed. The modulation appears as amplitude level shifts on the screen, and the frequency error of the oscillator is displayed as a phase drift. Rightward drift means the frequency is high and leftward drift means it is low. The rate of error can be exactly calculated from the following formula:

$$error\ in\ parts\ per\ million = \frac{16.7}{T}$$

where T is the time in seconds for one full sine wave to drift past a reference point on the screen. (See **fig. 1.**)

This creates a visual converter of very high Q. The screen's phosphorus persistence provides selectivity and the difference signal is detected as drift, easily measured in both direction and level. The result is an accurate method of frequency standard calibration at minimal cost.

using an existing oscillator

In most situations, one oscillator is established as the reference source. It can be used as a 100-kHz band marker, the master oscillator of a phase-locked loop scheme, or as the standard oscillator in a frequency counter. This reference oscillator should be calibrated by phase comparison to WWVB.

To properly use this circuit for calibration, it is necessary that the oscillator signal be brought out of your existing equipment and be processed so that a suitable submultiple frequency is available. Do some individual planning before beginning construction.

Digital division is usually necessary as the oscillator frequency will be higher than 60 kHz. Most equipment has internal dividers so the subfrequency you need may already be available. Make sure that this source is not so heavily loaded by the interface circuit that stability is affected.

Suitable frequencies meet the following requirement:

$$frequency\ (Hz) = \frac{60000}{n}\ \ where\ n = 1,2,3....etc.$$

By John A. Cowan, W4ZPS, 303 Kingston Highway 293 NW, Cartersville, Georgia 30120

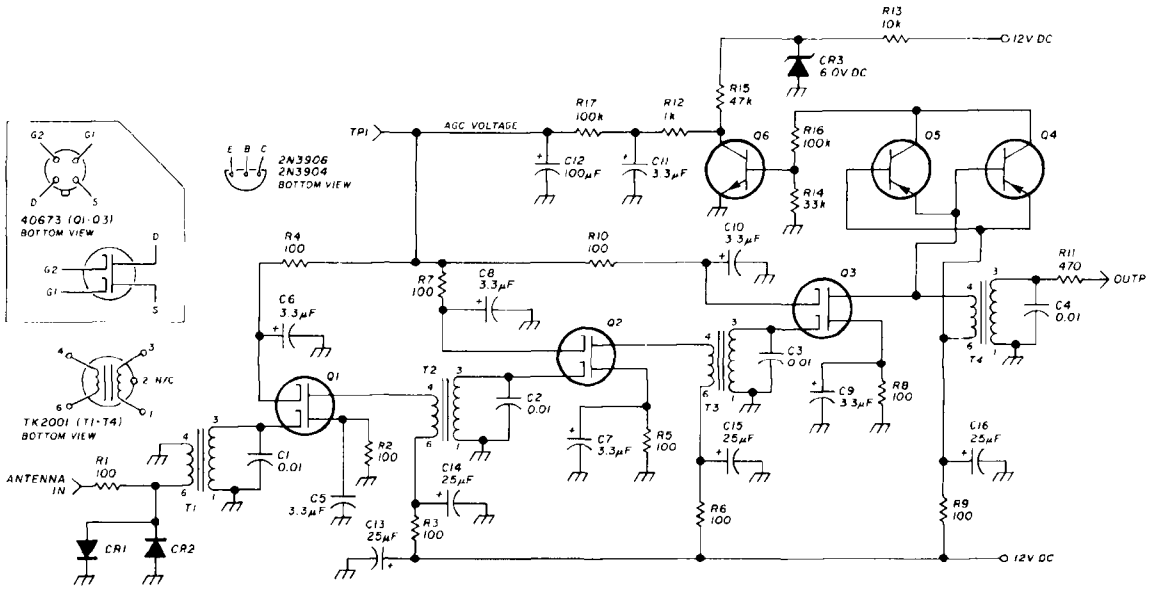


fig. 1. 60 kHz "receiver" diagram and inset drawings showing i-f transformer and transistor pinouts. All capacitors are in microfarads and all resistors 1/4 watt except R1.

parts list

CR1,CR2	*1-amp general purpose power diodes*
CR3	*6.0-volt Zener diode, 1 watt*
C1-C4	*0.01µF 100-volt mylar capacitors (Jameco No. MY.01/100)*
C5-C11	*3.3µF 35-volt dipped tantalum (Jameco No. TM3.3/35)*
C12	*100µF 6-volt dipped tantalum (Jameco No. TM100/6)*
C13-C16	*25 µF 25-volt electrolytic capacitors*
R1	*100-ohm 1/2-watt resistor*
R2-R10	*100-ohm 1/4-watt resistors*
R11	*470-ohm 1/4-watt resistor*
R12	*1-k 1/4-watt resistor*
R13	*10-k 1/4-watt resistor*
R14	*33-k 1/4-watt resistor*
R15	*47-k 1/4-watt resistor*
R16,R17	*100-k 1/4-watt resistors*
T1-T4	*1-mH i-f transformers (Digi-Key No. TK 2001)*
Q1-Q3	*40673 MOSFETs (Jameco No. 40673)*
Q4,Q5	*2N3906 PNP transistors*
Q6	*2N3904 NPN transistor*

A 100-kHz oscillator need only be divided by 10 since the resulting 10 kHz is a suitable submultiple (n = 6). A 1, 2, 3, or 6-MHz signal could be divided by 100 as 10, 20, 30, and 60 kHz also work (n = 6, 3, 2, 1). Oscillators at 4, 5, and 10 MHz must be divided by 1000. Division by 1000 works for all the above frequencies because further division of a suitable frequency always gives another. The only drawback in using higher than minimum division ratios is that fewer sweeps per second mean a dimmer display. Some frequencies are selected for use in binary schemes and will need division by binary counters. Rarely does a frequency require complex divide-by-n circuitry.

crystal oscillators aren't perfect

There's no such thing as long term stability in crystal oscillators. Even the best commercial circuits drift as the crystals age. The best that can be hoped for is to minimize short term drift from voltage changes, loading, and ambient temperature variations. Once tuned to frequency, these oscillators drift slowly and at a constant rate. Eventually, however, the cumulative effect of crystal aging will leave the frequency far from its mark. These are the times when this circuit and WWVB come to the rescue.

antenna considerations

Many antenna designs are suitable for use at 60 kHz. Loops, top-loaded verticals, and elaborate long-wire arrays all work well. However, when only reception is important, and cost the major factor, a *short* long wire and good earth ground are hard to beat.

One good technique uses a run of RG-59/U coax to exit the building and then attach the braid to a good earth ground. From this point, attach a length of wire to the center conductor and run it as far as possible. On small lots, running around the perimeter of the property gives good results. One leg of a dipole antenna may work well, but make certain that baluns and matching networks don't attenuate at 60 *kHz*. Power lines and color television sets generate significant interference at VLF, so locate the antenna as far away from these sources as possible.

Neither height nor great length is absolutely necessary. Even at my rather fringe location, I have received usable signals on a 30-foot wire running across the basement floor. My primary antenna is somewhat

longer and made of well-insulated wire *buried* 3 feet. underground!

In every case,a good (but not necessarily elaborate) earth ground is *essential.*

propagation

For about an hour, around sunrise and sunset along the main propagation path, signal strength and phase coherence are unreliable. During daylight hours (high sun angles) signals arrive entirely by ground wave and measurements performed then are theoretically most accurate. However, daytime weather along the route and noise spikes from power lines may be problems at times.

At night, particularly at some distance, sky wave propagation is a factor. Initially, ground and sky wave may be of near equal strength, alternately canceling and reenforcing one another, giving rapid phase shifts, and affecting reliability. Later, sky wave can dominate, providing significantly higher signal strengths while weather noise decreases. This improved signal-to-noise ratio makes the binary information easier to decode, although the varying path length will affect accuracy.

circuit description

The actual circuit design (see fig. 2) is straightforward with only a few necessary subtleties. Q1, Q2, and Q3 are used as variable gain amplifiers, which along with T1, T2, T3, and T4 form an RF amplifier having moderate selectivity. Q4 and Q5 have emitter-base junctions wired back-to-back, which clip the peak output voltage and along with Q6 derive an AGC voltage that is fed back to gate 2 of the MOSFETs. The AGC time constant is selected to prevent noise spikes from desensing the amplifier while being slow enough *not* to demodulate the a-m signal. A 100-ohm 1/2-watt resistor with back-to-back diodes is included at the input for lightning protection. The AGC voltage is available at TP1.

construction

At VLF layout is not critical and any reasonable materials, including perfboard, may be used. I prefer to build on one side of a copper-clad board and tack solder all components to this surface. Major components are glued or soldered to the surface and smaller pieces suspended in between. With care and practice, circuits can be quickly assembled, easily modified, and result in a finished product of surprising mechanical stability.

To begin construction, drill four holes in a row about 1 inch (25 mm) apart and ream them out to snug fit coils T1 to T4. Make their bases level with the working surface. Bend those terminals that need to be grounded 90 degrees and solder directly. Capacitors



fig. 2. Single-sided solder tack construction technique is fast and mechanically/electrical sound. A few circuit improvements have been made so schematic differs slightly.

and diodes can be soldered from the proper lugs to ground with short leads. Suspend the 40673 MOSFETs upside down by the coil lugs for the gate 1 and drain, the 100-ohm source resistor and bypass for the source, and the bypass capacitor for gate 2. Take care that the case doesn't actually contact ground. The other components are suspended between the MOSFETs and the circuit board. The board can be used for support wherever a bypass capacitor is needed. Connect power and the test point (TP1) by feedthrough capacitors and the input and output signals by coax connectors or phono jacks.

alignment

Verify the wiring. Now connect a jumper between TP1 and ground to reduce the receiver gain to a minimum. Apply 12 to 15 VDC and check the current (should be 10 to 15 mA). Check the voltage from source to ground at each transistor. This should read between 0.2 and 0.4 VDC.

Connect a 60-kHz frequency source to the input and connect an oscilloscope to the output. An audio oscillator can be used, but be careful that the frequency is within 100 Hz. Peak the coils starting with T4 and work backward, reducing the input when necessary to keep all stages in a linear range.

If there is a problem, connect the oscilloscope to gate 1 of Q2 and peak T1 and T2. Then move the probe to Q3 and peak T3. At this point reconnect to the output and retune T4 through T1. When properly tuned, selectivity is sharp and there will be a rapid drop-off as the test oscillator is tuned off frequency.

At this point the receiver is ready for operation. Make certain you have a reference signal that can trigger the scope and is at a suitable submultiple frequency. To check this, connect the audio oscillator to the vertical input and with the sweep time at about 5 microseconds/cm, see if the sine wave can be frozen (synchronized) as the frequency is edged through 60 kHz.

Now connect the antenna to the receiver's input and the output to the vertical channel of the oscilloscope

Join AMSAT...Today

Amateur Radio Satellite OSCAR 10 provides:

- **A New Worldwide DX Ham Band** open 10 hours a day.
- **Rag Chew With Rare DX Stations** in an uncrowded, gentlemanly fashion.
- **Popular Modes In Use:** SSB, CW, RTTY, SSTV, Packet
- **Full Operating Privileges** open to Technician Class licensee or higher.

Other AMSAT Membership Benefits:

Newsletter Subscription: Dependable technical articles, satellite news, orbital elements, product reviews, DX news, and more.

Satellite Tracking Software Available for most popular PCs.

QSL Bureau, AMSAT Nets, Area Coordinator Support, Forum Talks

Construction of Future Satellites For Your Enjoyment!

AMSAT Membership is $24 a year, $26 outside North America. VISA and MC accepted.

AMSAT
P.O. Box 27
Washington, DC 20044

301 589-6062

247

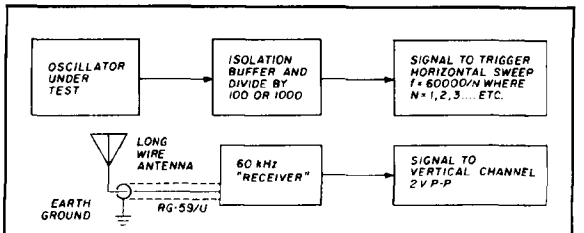


fig. 3. Interconnections needed for phase comparison.

(see fig. 3). WWVB should appear after the AGC level adjusts.

WWVB locking problems

There are many factors that frustrate attempts to directly phase lock an oscillator to WWVB. The most obvious is that the signal is erratic during certain times of the day and a tight locking scheme could go awry. Secondly, for identification purposes, the signal phase is advanced 45 degrees at 10 minutes past each hour and returned at 15 past. There will be instability unless offset circuitry is included. To avoid instability and other problems, you must start with a standard that is capable of maintaining short term stability of 0.0001 ppm (parts per million) per day or better. Compare the phase daily when ground wave is dominant and compute the aging rates. Error correction information can then be fed back digitally to the oscillator control whenever necessary, irrespective of signal conditions.

A more practical solution is to build or access the most stable oscillator possible and use this circuit to verify accuracy and, if necessary, make periodic adjustments using WWVB.

conclusion

WWVB can be received at most locations in the United States using minimum circuitry and reasonable antenna systems. With an oscilloscope and a few divider ICs almost any oscillator can be calibrated to 0.01 ppm or better. Calibration and temperature compensation of oscillators are facilitated because both the amount and the direction of frequency error are conveniently displayed.

sources of parts

Digi-Key Corp., POB 677, Thief River Falls, Minnesota 56701

Jameco Electronics, 1355 Shoreway Road, Belmont, California 94002

bibliography

NBS Special Publication 432, U.S. Department of Commerce, National Bureau of Standards, Washington, DC 20234

ham radio TECHNIQUES

Bill Orr W6SAI

the "radio ground" on 160 meters

My good friend Stew Perry, W1BB, is an avid 160-meter operator. He once told me that a fine "top-band" compromise antenna for hams with little space was an extended Marconi working against a good ground system. Taking his advice, I put up a 165-foot, series-tuned long wire (resonant at 1500 kHz) working against ground (**fig. 1**).

The ground consisted of the cold water copper pipes in the house, plus two ground rods -- one at each end of the house — and a single quarter-wave radial wire running through the bushes about 2 feet above the ground.

This antenna worked quite well. However, when I went on 160 the ceiling light in the family room lit up! Obviously, the rf was getting into the house wiring somehow.

Using an MFJ-206 Antenna Current Probe, tuned to 160 meters, I started "sniffing" the house wiring for rf energy. Aha! I could put the transmitter on low power, lock the key, walk through the house with the probe, and actually trace the electric wires hidden in the walls. The house's whole electrical system was "hot" with rf.

My first thought was that the wiring was picking up induced rf energy merely by being in the near field of the antenna. But the amount of rf measured seemed too high, considering the physical separation of the Marconi antenna from the house. If this was not the path, what was?

The probe indicated that the power cable to the transceiver was full of rf energy. Most confusing. The rig actually had two grounds on it, didn't it? They were the radio ground system I installed, plus the neutral and ground conductors of the power line (**fig. 2**). A little thought revealed the problem.

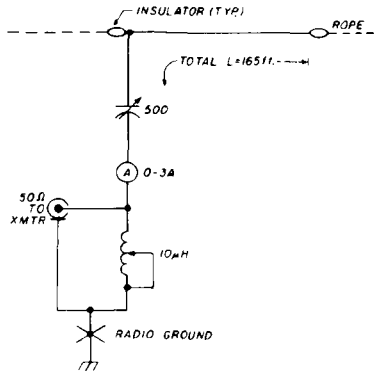


fig. 1. The series-tuned Marconi for 160 meters depends on a good radio ground to function properly. Do not let the power distribution ground get mixed up with the radio ground.

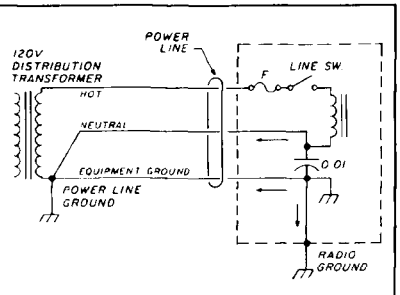


fig. 2. RF ground currents reach earth via the equipment power line as well as by the radio ground (arrows). RF and radio grounds should be decoupled by placing an rf choke in the power line.

separating the radio and electrical grounds

Figure 2 shows that two ground points exist: the intentional radio ground at the equipment, and the electrical ground at the power distribution transformer. The latter serves as a radio ground, as rf ground currents in the antenna circuit return via both paths. The unwanted path through the power cable is closely coupled to the other power conductors and feeds rf energy into them. And, if the power wiring has appreciable impedance at 160 meters, any rf fed into the power line can wander into some very unlikely places.

My solution was to wind the line cord of the transceiver around a ferrite rod (Amidon R-33-050-750), 7-1/2 inches long, and 1/2 inch in diameter. This was held in place by two plastic cable wraps. The rf antenna current immediately increased 30 percent (!) after the line choke was installed. Encouraged by this success, I took an 8-foot extension cord, wrapped it around a second ferrite rod, and placed it in series with the first line choke. This increased the antenna current an additional 5 percent and the family room light did not go on when I hit the key.

I "sniffed" the house wiring with the probe again. There was still a little rf present, but it was greatly reduced. It looked as if the problem was solved.

problems with a linear amplifier

Now that everything had cooled off, I decided to put my 160-meter, homemade linear amplifier on the air. It uses a single 3-500Z and runs about 1-kW PEP input.

As I fired it up, a loud cry came from the other end of the house. The family room lights magically turned themselves on, along with the light in the entry hall!

Since I had used up all my ferrite rods, I found a fine industrial rf filter for the 240-volt line in the junk box. It was a well-known brand built in a nice plastic box with heavy conductors on each end (**fig. 3**). Unfortunately, placing it in the power line to the amplifier made no difference in the amount of rf in the power line.

It seemed that the impedance of the power line neutral wire was sufficiently high at 160 meters to allow the neutral to rise above rf ground at the filter. If this guess was correct, the capacitors in the filter served merely to bypass the rf around the line chokes.

Grounding the common point of the capacitors to the radio ground at the amplifier helped but did not solve the problem. Now the amplifier had a radio ground point, plus two power line ground points: one at the distribution transformer and a second at the transmitter radio ground. This complex grounding situation left me uneasy, so I tossed out the 240-volt line filter and wrapped the power cord to the amplifier around two ferrite rods held together with plastic tape. (I used two rods because the amplifier power cable was heavy and difficult to wrap around a single rod.)

I was happy to note that the lights no longer blinked as I keyed the amplifier. All was as it should be. Thus I learned that when a Marconi antenna is used, the ground system may be more complex than it looks. It is important to decouple the power line from the rf ground system, and the easiest way to do this is to wrap the power cable around a ferrite rod. The old-style line filter made up of inductors and capacitors just doesn't do the job if the neutral line is used as the filter return ground point.

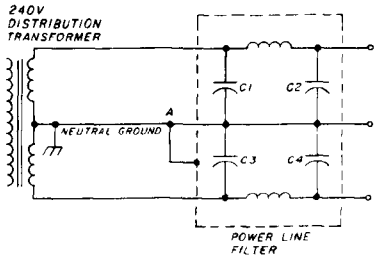


fig. 3A. Typical power line filter. If a metal box is used, it is grounded to neutral wire.

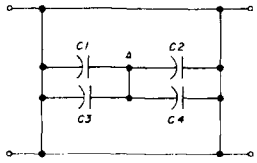


fig. 3B. If rf impedance of power line is high at the operating frequency, the ground return point A is not at ground potential and line capacitors act as bypasses around the line chokes.

a two-band dipole antenna

Much is written about two-band antenna designs using tuned traps in the radiating element. A different approach is shown (**fig. 4**) in a design by Ron May, VK1PM.

This dipole covers the 80 and 40-meter bands. On 40 meters, the center section of the antenna acts as a folded dipole with a feedpoint impedance of about 300 ohms. The end sections, each a quarter wavelength long, are decoupled from the antenna and act as linear traps. On 80 meters, the full length of the antenna forms a half-wave element, fed with a T-match to the 300-ohm feedpoint. A 300-ohm TV-type feedline, with a 6:1 balun at the end, is used to match a nominal 50-ohm feedpoint (Palomar PB-6 balun). A coax line runs from the balun to the station. Overseas Amateurs using 75-ohm coax can use a 4:1 balun.

The idea can be applied to any two harmonically related bands, such as 40/20, or 20/10 meters.

HB9ADQ delta loop for 7/14/21/28 MHz

The delta loop shown in **fig. 5** can operate on four bands. Maximum current is in the horizontal wire for best low angle radiation. The loop can be slung between two trees for ease of installation. Maximum radiation is at right angles to the plane of the loop (into and out of the page).

The loop is fed with a two-wire transmission line. The original design called for a 600-ohm line, which could be made up easily by any old-timer who has had experience building a Zepp antenna. Modern substitutes are the Saxton Products Corp. 1562 insulated open wire line (using a polyethylene web) or the 2500 open-air line. The length of the line is adjusted for minimum SWR on the coax feedline. When the 600-ohm line is used, a 20-pF capacitor is connected across the feedpoint.

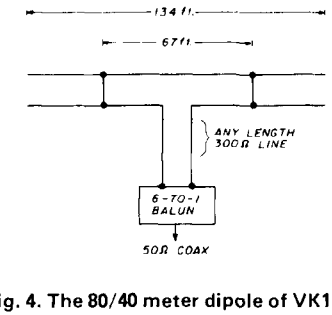


fig. 4. The 80/40 meter dipole of VK1PM is made of 300-ohm twin lead, as is the feeder. Jumpers between the two conductors are placed as shown. The end wires of the dipole are left open.

The open wire line can be extended to reach the station where it is fed with an antenna tuner that provides balanced output in the range of 100 to 600 ohms.

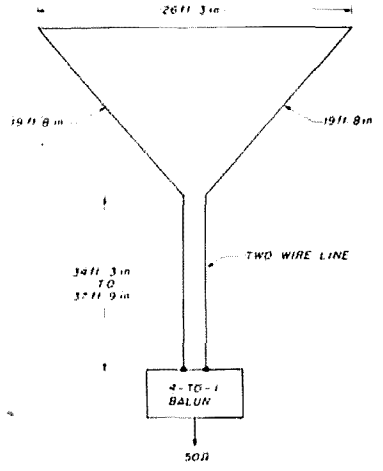


fig. 5. Four-band loop for 7/14/21/28 MHz. Balanced feedline and balun provide match to 50-ohm coax. Adjust length of two-wire line for lowest SWR on coax.

The loop need not be in the vertical plane. It can be laid on the side or at a 45 degree angle and still do the job.

ham radio

SPECIALIZED COMMUNICATIONS

FOR TODAY'S RADIO AMATEUR!



Our 20th Year!

Since 1967, covering all modes of Amateur Radio "specialty" communications; Fast Scan TV, SSTV, FAX, Packet Radio, Computers, RTTY, AMTOR, Satellites, TVRO, Microwave, Lasers and more! 10 issues per year. Back issues available, SASE brings TRS80C, C64, IBM software catalog. U.S. subscribers $20/year. Foreign slightly higher. Add $2.00 for Index Issue.

SPEC-COM Communications & Publishing Group
P.O. Box H
Lowden, Iowa
52255-0408

VISA MasterCard
5% Added

1988 CALLBOOKS



The "Flying Horse" sets the standards

Continuing a 67 year tradition, we bring you three new Callbooks for 1988.

The North American Callbook lists the calls, names, and address information for 478,000 licensed radio amateurs in all countries of North America, from Canada to Panama including Greenland, Bermuda, and the Caribbean Islands plus Hawaii and the U.S. possessions.

The International Callbook lists 481,000 licensed radio amateurs in countries outside North America. Its coverage includes South America, Europe, Africa, Asia, and the Pacific area (exclusive of Hawaii and the U.S. possessions).

The 1988 Callbook Supplement is a new idea in Callbook updates, listing the activity in both the North American and International Callbooks. Published June 1, 1988, this Supplement will include thousands of new licenses, address changes, and call sign changes for the preceding 6 months.

The 1988 Callbooks will be published December 1, 1987. See your dealer or order now directly from the publisher.

☐ North American Callbook	
incl. shipping within USA	$28.00
incl. shipping to foreign countries	30.00
☐ International Callbook	
incl. shipping within USA	$30.00
incl. shipping to foreign countries	32.00
☐ Callbook Supplement, published June 1st	
incl. shipping within USA	$13.00
incl. shipping to foreign countries	14.00

SPECIAL OFFER

☐ Both N.A. & International Callbooks	
incl. shipping within USA	$55.00
incl. shipping to foreign countries	60.00

Illinois residents please add 6½% tax.
All payments must be in U.S. funds.

RADIO AMATEUR **callbook** INC.
Dept. F
925 Sherwood Dr., Box 247
Lake Bluff, IL 60044, USA

Tel: (312) 234-6600 VISA MasterCard

Above and Beyond
AR2002

PROFESSIONAL MONITOR RECEIVER

25 – 550 MHz
800 – 1300 MHz



Specifications:

Receiving mode – Narrow band FM, Wide band FM & AM
Receiver circuit – Microprocessor controlled PLL Frequency synthesized superheterodyne type with high-level doubled balanced mixer
Receiver IF – 750MHz, 45.03MHz, 5.5 MHz (WFM) and 455kHz (NFM & AM)
Sensitivity – NFM – 0.35 uV (12dB SINAD)
WFM – 1.00 uV (12dB SINAD)
AM – 1.00 uV (10dB S/N)
Selectivity – NFM – ±7.5kHz @ 6dB
±20kHz @ 70dB
WFM – ±50kHz @ 6dB
±250kHz @ 60dB
AM – ±5.0kHz @ 6dB
±10kHz @ 70dB
Number of memory channel – 20 channels
Scan rate – 5 channels per second
Search rate – 6 seconds per MHz
Antenna connector – Standard BNC type, 50-ohm
Audio output power – 1 watt at less than 10% THD
Power requirement – 12 to 14Vdc at 300 to 500mA
Size and weight – 5.47"W x 3.15"H x 7.88"D, 2.6 lbs.

Options:

Please-No-Dealer-Inquiries

AR2002
Professional Monitor Receiver
$455.00
(California res. add $27.30 tax)

Visa and MasterCard accepted
Prices includes shipping & handling
C.O.D. slightly higher

22511 Aspan Street, Lake Forest, CA 92630-6321
Calif./Alaska (714) 581-4900
Facsimile (714) 768-4410 (not a phone)
TOLL FREE 1-800-523-6366

ACE communications, inc.

amateur packet radio
networking and protocols: part 2

OSI/RM levels and the AX.25 packet radio protocol

This is the second article in a three part series on networking and protocols in amateur packet radio. Last month I introduced the subject of networks and protocols with examples of various systems.

Part 2 gives more detailed information on the initial layers of the OSI/RM introduced in Part 1 and their relation to amateur packet radio. Also examined is the AX.25 packet radio protocol. Portions of this series are excerpted from my book, *The Packet Radio Handbook*.*

OSI/RM and amateur packet radio

There are three levels of OSI/RM (Open Systems Interconnection Reference Model) currently implemented in amateur packet radio in the United States: the physical, data link, and rough forms of the network layer. We will discuss the first two. Levels and protocols now under development will be covered in Part 3.

physical layer

The physical layer is well prescribed and the Bell 202 and 103 are its most widely used modulation standards. The RS-232C asynchronous serial interface is another physical layer standard and more should emerge when high speed modems and new modulation schemes are developed.

Encoding technique is an area of the physical layer involved in transmission of data which defines the format of the modulated signal. In RTTY and Amateur packet radio, a bipolar format is used. In bipolar keying, two different levels are used to represent a 1 and a 0. This is an improvement over unipolar keying where a single tone indicates a 1 and the absence of a tone a 0. (See **fig. 1.**)

Bipolar keying takes several forms. NRZ (NonReturn to Zero) or NRZ-L (NRZ-Level) is used by regular Baudot RTTY and AMTOR. In NRZ, a 1 is represented by a particular level or tone, and a 0 by another. See **fig. 2.**

NRZ-I (NRZ Inverted) or NRZ-S (NRZ Space) is the bipolar method employed by most packet radio stations and supported by all manufactured TNCs. In NRZI, a binary 0 causes a switch (or transition) between signal levels while a binary 1 remains at the current level. The two signal levels can also be referred to as "mark" and "space" levels.

Other forms of bipolar keying encoding techniques are: NRZ-M (NRZ-Mark; the opposite of NRZ-S), PPM (Pulse Position Modulation), PDM (Pulse Duration Modulation), and Manchester I and II. These and other encoding techniques are discussed on pages 19-39 of the 1986 ARRL Handbook.

data link layer

The data link layer in amateur packet radio is also well prescribed. The AX.25 protocol is the most common and is supported by the majority of commercial TNCs. The V-1 (VADCG—Vancouver Amateur Digital Communications Group), and V-2 protocols are other data link layer protocols. These differ from AX.25 in many respects, however, all three protocols are based on the HDLC ISO standard.

HDLC

High-level Data Link Control (HDLC) is the data link layer (level 2) of X.25 and is defined in the following ISO standards: ISO 3309, ISO/DIS 4335, ISO/DIS 6156, and ISO/DIS 6259. HDLC is responsible for

By Jonathan L. Mayo, KR3T, 1817 Saratoga Court, Allentown, Pennsylvania 18104

*Available from the *ham radio* Bookstore for $14.95 plus $3.50 shipping and handling.

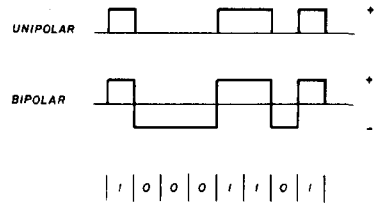


fig. 1. Keying techniques: Unipolar vs. Bipolar.

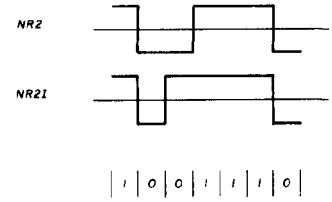


fig. 2. Encoding techniques: NRZ vs. NRZI.

delivering error free data throughout the network. It also isolates the upper levels from the physical layer. Data is broken up into blocks (frames) for transmission. The user data (actual data sent through the network by the users) is called data or information.

HDLC consists of three sublayers: 1) transparency of the bit stream, 2) frame format, and 3) cooperation between stations. Before continuing this discussion of HDLC, an explanation of the differences between COPs and BOPs is necessary.

COP stands for Character Oriented Protocol. Two examples are ANSI X3.28 and IBM Binary Synchronous Communication. In a COP, the data being sent must be represented as characters of specified length — usually seven or eight bits (one byte) — so there is a limit to the type of information that can be transmitted. All transmission lengths must be a multiple of the specified character length. COPs are helpful if just text is being transmitted, but less useful in packet radio which is designed to send any type of digital data including characters of different lengths, graphics, and special formats. In packet radio, transmission size must also be condensed as much as possible. BOPs (Bit Oriented Protocols) come in handy here.

BOPs permit the transmission of any format of digital data. A good example of a BOP is HDLC along with the amateur packet radio data link layer protocols. If control information is only 3 or 4 bits long, BOPs will only consume 3 or 4 bits, not a full 7 or 8 as COPs do.

In the first sub-layer of HDLC, transparency of the bit stream, all data being transmitted must be packaged the same. HDLC must be independent of the data sent and simply delimit (mark the beginning and end) frames. No special length bits or signaling elements can be used and all data should pass through the physical layer without alteration or processing. A flag — a special binary sequence found only at the beginning and end of a frame — is used to do this. The flag used in HDLC is 01111110 and must not appear anywhere else in the frame.

To keep flags out of the user data, the information is examined, and a 0 is inserted after every five consecutive 1 bits. This is called *bit stuffing*. The receiving station corrects for this by removing the stuffed bit after a sequence of five 1s if it is a 0; if the bit is a 1, it will not be removed as the sequence of ones is part of a flag.

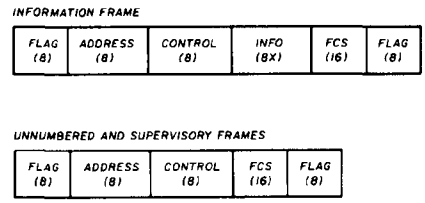


fig. 3. HDLC frames. The numbers in parenthesis indicate the total number of bits in that particular field. The information field is usually a multiple of eight bits.

In the second sub-layer, the frame format, all data is segmented and sent in frames delimited by flags. The components of the frame between the two flags are: addresses, control information, data, and the FCS (Frame Check Sequence). **Figure** 3 shows the HDLC frames. Frame components are described below.

The first frame component following the initial flag is the address. In HDLC this includes the address of the originating and destination station. The addresses are usually numerics, but AX.25 uses callsigns instead of numbers and includes digipeaters in this section.

The next section (or field) in the HDLC frame is control information. Depending on the type of frame, control information can consist of several things. The three types of frames defined under HDLC are: information, supervisory, and unnumbered. The control field is made up of 8 bits.

Information frames are used for data transfer (to carry user information). Bit 1 of the control field of an information frame is a 0, bits 2 through 4 represent the transmitting station sequence number (often called transmit count), bit 5 is the poll/final bit, and bits 6 to 8 represent the receiving station sequence number (receive count).

Supervisory frames are used to control data flow.

Bit 1 of a supervisory frame's control field is a 1, bit 2 is a 0, and bits 3 and 4 represent the supervisory frame type indicator. Bit 5 is the poll/final bit, and bits 6 to 8 show the receive count.

Unnumbered frames control the link. Bits 1 and 2 of the control field of an unnumbered frame consist of ones, bits 3 and 4 are modifier bits, bit 5 is the poll/final bit, and bits 6 to 8 are modifier bits.

Each station involved in a link maintains counters for the number of information frames sent and received. These counters are the "sequence number" or "count". They are sent in the control field of each information frame, and used to check the sequence of received frames and acknowledge their reception.

The HDLC frame component next to the final flag is the FCS. The FCS is a cyclic redundancy check (CRC) performed on a frame – an error detection scheme in which a check character is generated by dividing the entire numeric binary value of a block of data by a generator polynomial. The FCS value is sent along with the data, and at the destination station, is recomputed from the received data. If the received FCS matches the one generated from the received data, the data is considered error free.

Computation of the FCS starts with the first bit after the opening flag and ends with the last bit preceeding the FCS. For details on FCS methods, see ISO standard 3309.

Cooperation between stations, the last sub-layer, is handled by special frames recognized by HDLC as commands and responses. Three tasks of command and response frames are to establish connections, acknowledge receipt of frames, and handle disconnects. Specifics of the different commands and responses used by HDLC to manage the link layer in Amateur packet radio are discussed under the appropriate protocols.

AX.25

AX.25 has become the standard level 2 protocol in Amateur packet radio. It is very similar to the level 2 protocol of the X.25 standard; thus the name 'AX.25' ('A' is for Amateur). The original version of AX.25 has been around for a while and minor incompatibilities existed between various implementations until the ARRL Ad Hoc Committee on Amateur Digital Communications finished a revised version of the AX.25 standard in 1984.

The ARRL version of AX.25 is called *AX.25 Version 2* and the earlier AX.25 protocol is now *AX.25 Version 1*. The more popular AX.25 Version 1 protocol was developed by Tucson Amateur Packet Radio (TAPR). There are both similarities and incompatibilities between these versions of AX.25.

AX.25 follows the same frame format as HDLC. The main differences are that 1) the address field has been extended to permit amateur radio callsigns as addresses and 2) unnumbered information frames may be transmitted.

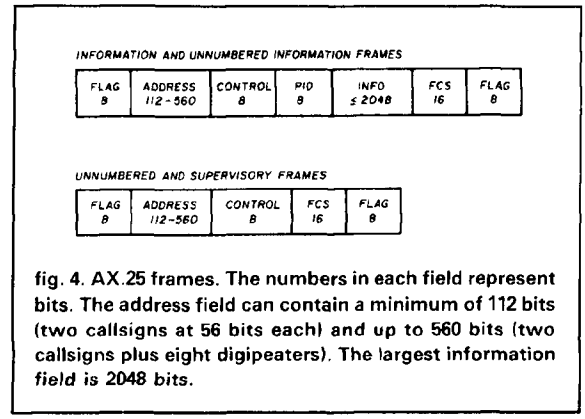


fig. 4. AX.25 frames. The numbers in each field represent bits. The address field can contain a minimum of 112 bits (two callsigns at 56 bits each) and up to 560 bits (two callsigns plus eight digipeaters). The largest information field is 2048 bits.

A description of the various components of an AX.25 frame (see **fig. 4**) follows.

The flag is identical in function and design to that used in HDLC.

The address field is made up of a minimum of one amateur radio callsign belonging to the sending station in a unnumbered information frame (the destination is set to a dummy address). In most cases, the destination station's callsign is included. Up to eight digipeater callsigns may also be added. There is a maximum number of ten callsign addresses in the AX.25 address field.

Each callsign requires seven groups of eight bits (eight bits = one byte = one character or an 'octet'). Callsigns consist of uppercase ASCII characters and numbers. The first six characters are allotted for the actual callsign; if the callsign is less than six characters in length, spaces are added to the end. The seventh character is the SSID (Sub-Station IDentifier or Secondary Station IDentifier) and ranges from 0 to 15. Only four bits of the eight available for the SSID are used. The first and last bits are set to 0 and the remaining two are reserved for future use.

The SSID of a digipeater carries additional information. To avoid a digipeater repeating a frame twice, the last bit of the SSID is set to 1 once the frame has been digipeated by that station.

The control field is made up of one eight bit group (an octet) and is used to identify the type of frame: information, unnumbered, unnumbered information, and supervisory. It also contains the frame count numbers used for acknowledgements and special signals for establishing and maintaining connections (commands and responses).

A Protocol IDentifier Field (PID) is included with information frames. It identifies what kind of network layer protocol, if any, is being used.

The information field contains the user data being transmitted and is most often divided into a multiple of octets; the maximum is 256.

The FCS is the same as that used in HDLC.

Each transmission is usually preceded by a series of sixteen alternating bits giving the receiving station time to synchronize to the signal.

AX.25 is actually a subset of the HDLC standard as it does not implement the full range of features defined in HDLC. It is based on the LAPB (Link Access Procedure Balanced) subset of HDLC.

In a "normal" HDLC network, there are frequently several slave stations (user terminals) linked to a central controller or host system (also called a primary or master station). The master station is usually more "intelligent" than the slave stations and better able to manage the link. This configuration, with one intelligent master station linked to a less intelligent slave station, is *unbalanced* because the stations possess unequal capabilities.

In amateur packet radio, the goal is for each station to have equal capability in a balanced configuration eliminating the need for a master or host station. This type of station arrangement is supported by LABP under HDLC.

A discussion of the frames used by AX.25 to establish connections, acknowledge frames, and disconnect follows.

Unnumbered frame control fields are either commands or responses. Unnumbered frames handle all communications between stations when no connection has been established. There are six different unnumbered frames defined in AX.25.

SABM (Set Asynchronous Balanced Mode) is a command which sends a connect request to another station. The control field in this frame contains a special sequence of bits identifying it as a SABM frame. The SABM command places two stations in *asynchronous balanced mode* (meaning they are connected).

DISC, the next unnumbered frame and another command, is used to send a DISConnect request terminating a connection with another station.

DM (Disconnect Mode), is a response sent whenever a station receives any frame other than a SABM while disconnected. It can also be sent in response to a SABM frame to indicate the station is not available.

The **UA** (Unnumbered Acknowledge) response is sent as an acknowledgment for unnumbered frame commands. A received command is not executed until a UA frame has been sent.

FRMR (FRaMe Reject) is also a response. It is sent when a station receives a frame that cannot be processed. This response is usually sent when a frame clears the FCS check but is not recognized by the station's protocol. Two situations when this might occur are the reception of a command or response not defined in the protocol, or an information frame whose information field exceeds the maximum allowable length.

UI (Unnumbered Information) is an addition to the X.25 protocol included in AX.25. The UI frame lets an information field be transmitted without first establishing a connection. These frames are not acknowledged.

Once a connection is established using the above commands and responses, AX.25's function is to transfer error free data between the two stations. It does this by using one of three of supervisory frames.

The **RR** (Receive Ready) response indicates that the sending station is able to receive information frames, acknowledge the reception of information frames, and clear an RNR response previously set by the station. The RR frame acknowledges the reception of information frames by including the receiver count indicating which frames have been correctly received. The other station can examine the count and update the next packet to be sent according to what frames can now be "forgotten".

To indicate that the sending station is temporarily busy and unable to accept more information frames, a **RNR** (Receive Not Ready) response is sent. This might occur when the receive station's buffer is full and it sends an RNR to the other station telling it to hold further information frames until the buffer can receive them. The RNR condition can be cleared by sending a UA, RR, REJ, or SABM frame.

The **REJ** (REJect) response requests the retransmission of information frames received out of sequence. The frame(s) to be retransmitted are indicated by the receive count in the frame's control field. The REJ condition is cleared when the frames are properly received.

AX.25 follows certain steps when connecting and disconnecting from another station.

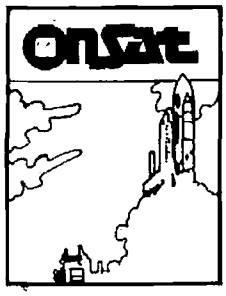
When a user types a "C KR3T" at the command prompt and presses the RETURN key, the TNC prepares a SABM frame containing the user's call and KR3T in the address field. The TNC then checks to see if the channel is available (CSMA) and transmits the SABM frame if it is.

KR3T receives the frame and finds its call in the destination address. If connect-ok (CONOK) is on and the TNC is free to establish a connection, KR3T sends a UA frame to the originating station and is connected. If CONOK is off, KR3T sends a DM frame to the originating station.

Assuming KR3T is available and the originating station has received the UA frame from KR3T, it too becomes connected and information frames are used to transfer data between them. Both stations keep receive and transmit counters current.

OnSat

"America's Weekly Guide to Satellite TV"



The best in satellite programming! Featuring: ★ Over 120 Channels listed ★ Weekly, Updated Listings ★ Magazine Format ★ Complete Alphabetical Movie Listings ★ Sports Specials ★ Prime Time Grids ★ Specials ★Programming Updates!

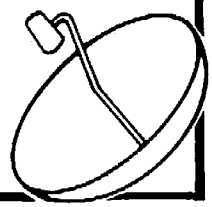
- **Only $45.00 per year (52 weekly issues)**
- **2 Years $79.00 (104 weekly issues)**
- **$1.00 for sample copy**

*NC Residents must add 5% Sales Tax

Subscribe Today!

call toll free 1-800-234-0021
Visa* and MasterCard* accepted

OnSat PO Box 2347 Shelby, NC 28151-2347



STV GUIDE

The new **STV Guide** contains valuable information on zoning regulations, scrambling, plus technical tips for installing or updating a satellite system—and now a precise monthly guide to satellite TV with the latest program listings for over **90 channels**!



All this in each complete issue of **STV Guide**!

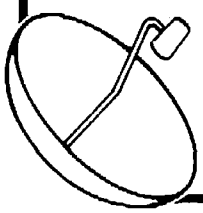
- **Only $48.00 per year (12 monthly issues)**
- **$2.00 for a sample copy**

*NC Residents must add 5% sales tax

Subscribe Today!

Call toll free 1-800-234-0021
Visa* and MasterCard* accepted

STV Guide PO Box 2384 Shelby, NC 28151-2384



The RR frame is used to acknowledge the receipt of information frames. If a frame is received out of sequence by one of the stations, it sends a REJ to the other and the frame is retransmitted.

When one of the stations wants to end the connection, he returns to command mode and enters "D" at the prompt. His TNC then sends a DISC frame to the other station which, in turn, sends him a UA frame acknowledging the disconnect request and breaking the connection. When the first station receives the UA frame, it also disconnects.

A few points in the previous section on the AX.25 link layer protocol may not seem to fit the description of the data link layer given in Part 1 of this series. These discrepancies include the addition of digipeaters and the use of end to end acknowledgements.

Digipeaters seem to fall under the control of the network layer protocol, not the data link layer, and in many respects this is true. However digipeaters are not, by any means, full fledged level 3 network nodes but rather a simple arrangement added to allow for rudimentary networking. The user must select the digipeaters used; the TNC does not contain automatic routing tables or other means of independently selecting digipeater routes. Digipeaters will most likely disappear as more advanced network nodes and level 3 protocols emerge.

In the OSI/RM the end to end acknowledgements would seem to be the responsibility of the transport layer (level 4). This layer is responsible for the proper reception of frames from station to station through the network. In AX.25 there is no network layer protocol implemented yet, so point to point acknowledgements of the data link layer are simply extended over the digipeater path. If the digipeaters are eliminated from the path, the acknowledgment returns to a point to point acknowledgment as used by the data link layer. Once network nodes are implemented, they will use point to point acknowledgments between nodes and a transport layer acknowledgment between the two end stations.

summary

This article detailed the first two levels of the OSI/RM as they relate to Amateur packet radio. Also included were a discussion of HDLC (upon which most current Amateur packet radio level 2 protocols are based), and an examination of the AX.25 data link protocol. Part 3, the final article in this series will cover other level 2 packet radio protocols and discuss the remaining layers of the OSI/RM.

If you have any questions or comments, you can write to me at the address listed or leave a message on CompuServe; my User ID is 72276,2276.

ham radio

258

PRACTICALLY SPEAKING ... Joe Carr K4IPV

parametric amplifiers

Parametric amplifiers can operate with very low noise in the UHF and microwave regions of the electromagnetic spectrum. Noise temperatures from 100 to 270 degrees Kelvin (1.4 to 2 dB noise figure) were reported in uncooled parametric amplifiers as early as 1970, and more recent devices offer even better performance.[1] As a result, parametric amplifiers are sometimes used as low noise amplifiers (LNA) in the input stages of VHF/UHF and microwave communications receivers.

The name *parametric amplifier* was chosen because amplification occurs through the excitation of a circuit parameter. This is actually a misnomer because it is the reactance parameters (X_C and X_L) that are excited. A better name might be *reactance amplifier*.[2] The parametric amplifier is fundamentally different from other LNAs because it uses a passive device for amplification. In this type of amplifier circuit a reactance is used as the amplifying element. A perfect reactor stores and discharges energy, but does not dissipate power. Capacitive reactors store energy in an electrostatic field, while inductive reactors store energy in a magnetic field. Parametric amplifiers store energy from an rf "pump" signal in the reactance, and then switch it to the load under the influence of the input signal. Addition of stored energy to the signal at the output of the amplifier causes power amplification.[3]

The parametric amplifier has low noise because reactances dissipate no power and ideally produce no Johnson (thermal agitation) noise. In practical circuits, resistive losses do occur and Johnson noise is present. By varying the reactance at a rapid rate, energy is stored and discharged by the reactance and is used to amplify the signal. Although either capacitors or inductors can be used in parametric amplifiers, the capacitive reactance is used in practical circuits because suitable voltage variable capacitance diodes ("varactors") are available. However, other processes inside a diode generate noise and while parametric amplifiers exhibit low noise factors, the level is *not* zero.

The capacitance of a varactor is a function of the reverse-bias potential applied across the PN junction of the diode. A typical varactor useful in parametric amplifiers has a breakdown voltage of −4 to −12 volts, and a zero-bias junction capacitance of 0.2 to 5 picofarads. The cutoff frequency should be 20 GHz or higher. Generally, noise figure improves with higher diode cutoff frequencies.[4]

Parametric amplifiers can be operated in either of three modes: *degenerative, nondegenerative,* and *regenerative*. We will consider these modes, and provide a tool for evaluating parametric amplifier circuits.

degenerative parametric amplifiers

Figure 1A shows a basic parametric amplifier. A varactor diode switches the signal on and off to the load as an external pump signal is applied. Although shown as a series connected switch, both series and parallel connected diodes can be used. The signal and pump waveform (see **fig. 1B**) are phased so that the diode capacitance is fully charged when the pump signal peak occurs. Because the charge is constant, the voltage increases by the relationship $V = Q/C$ in step with a pump voltage reduction of diode capacitance.

Parametric amplification occurs when the peak of the pump signal coincides with the positive and negative peaks of the signal waveform. As the pump voltage peaks the diode capacitance decreases to a minimum, and the capacitor's charge is dumped to the load. Phasing must be precise to achieve degenerative parametric amplification. This occurs when the pump frequency is twice the signal frequency. However, this precise phasing requirement means that drift in either signal can reduce the gain or prevent the circuit from operating. Using nondegenerative or regenerative parametric amplifier circuits is a broader bandwidth approach.

nondegenerative and regenerative parametric amplifiers

In a nondegenerative parametric amplifier a third frequency, known as an idler, f_i, is used in addition to the signal and pump frequencies, f_s and f_p. In **fig. 2** a third resonant tank circuit (L_3C_3) tuned to f_i is indicated. The idler is the output frequency of the circuit which also operates as a frequency translator or converter.

There are two general cases of non-

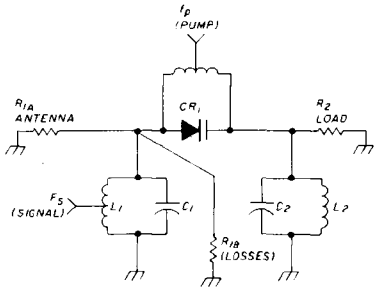


fig. 1A. Representative parametric amplifier circuit.

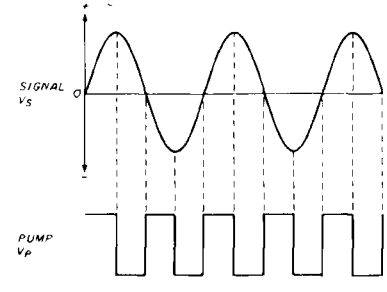


fig. 1B. RF and pump signal waveform timing.

degenerative parametric amplifiers: upconverters and downconverters. In the upconverter the idler frequency is the sum of the pump and signal frequencies:

$f_i = f_s + f_p$

In the downconverter, the idler frequency is the difference between pump and signal frequencies:

$f_i = f_s - f_p$

Power gain is defined as the ratio of the output to input power. In the case of a lossless circuit the gain of the upconverter (f_i greater than f_s) is:

$G = f_i/f_s$

The downconverter actually shows a loss (attenuation), rather than a power gain.

The third category of parametric amplifiers is the regenerative circuit, and is actually a special case of the nondegenerative amplifier. In the regenerative amplifier the pump frequency is the sum of the signal and idler frequencies. The power transfer direction is reversed, implying a negative resistance characteristic and the resulting circuit is regenerative. If prevented from oscillating, low noise and very high gain are achieved.

noise in parametric amplifiers

The low noise capability of the parametric amplifier results from the use of a reactance instead of a resistance for the amplifier element. In an ideal parametric amplifier the noise figure is zero.

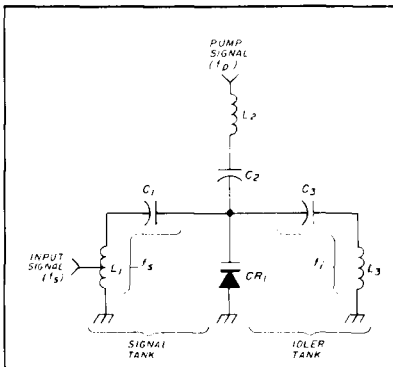


fig. 2. Non-degenerative parametric amplifier.

There are two noise contributions in practical circuits — circuit losses and frequency conversion noise. These sdurces combine to create a non-zero noise factor of the order:

$$F_{noise} = \frac{R_a}{R_l} + \frac{f_s}{f_i} \qquad (4)$$

Where:

F_{noise} is the noise factor

R_a is the antenna impedance resistive component

R_l is the sum of circuit resistance losses

f_i is the idler frequency

f_s is the signal frequency

As a rule of thumb, a pump frequency seven to ten times the signal frequency for lowest noise operation is chosen.

microwave configurations for parametric amplifiers

The circuit examples given show the use of discrete inductor-capacitor (LC) resonant tank circuits. These circuits work well up into the UHF and lower microwave region. At higher microwave frequencies, the LC tank circuit is impractical. At these frequencies parametric amplifiers use resonant cavities (**fig. 3**) in place of resonant tank circuits. Use a tuning disk to adjust the cavities to resonance.

Manley-Rowe relationships

In 1957 Manley and Rowe developed a way to evaluate parametric amplifier circuits.* Consider the equivalent circuit in **fig. 4**. We have a variable capacitance as the element and two signal sources: the signal frequency (f_s) and the pump frequency (f_p), both shown as generators. Filters in series with both generators pass the generator frequency and reject all others. There is also a series of loads, each isolated from the others by the same kind of ideal narrowband filter. The frequencies of these filters are: ($f_p - f_s$), ($f_p - f_s$), up to ($mf_p \pm nf_s$) (where m and n are integers). The Manley-Rowe relationships are:

$$I. \quad \sum_{m,n} \frac{m\,P_{m,n}}{mf_p + nf_s} = 0 \qquad (5)$$

$$II. \quad \sum_{m,n} \frac{n\,P_{m,n}}{mf_p + nf_s} = 0 \qquad (6)$$

In working with Manley-Rowe equations, the following algebraic sign conventions regarding power are used:

- + P is assigned to power flowing either into the capacitor, or from the pump and input signal "generators," and
- − P is assigned to power flowing out of the capacitor or into a load resistance.

The parametric amplifier's stability is determined by the sign of the power flowing with respect to the capacitor. If the power from the signal flows into the capacitor, the stage is stable. Because we deal with integers from 0

*See Liao and Coleman for discussions of Manley Rowe relationships. The Liao book derives the equations, while Coleman works out several examples.

through the *ith*, we can check not only the fundamental frequencies (m and n = 1), but also their respective harmonics (m,n > 1). Some of these combinations are stable; others are not. There are several cases where the Manley-Rowe equations apply. Let's consider only one to see how such problems are solved.

example

Consider a parametric amplifier in which an output frequency (f) is the sum of the pump signal (f_p) and the input signal (f) frequencies: $f = f_p + f_s$. Solve the Manley-Rowe equations to determine network stability.

solutions

First construct a table showing the signals and permissable values of m and n (we will consider only the fundamentals).

SIGNAL	m	n	$mf_p + nf_s = ?$	$P_{m,n}$
Input Signal	1	0	f_s	P_{10}
Pump	0	1	f_p	P_{01}
Idler	1	1	$f_p + f_s$	P_{11}

The first case (Manley-Rowe I) can be rewritten in the form:

$$\frac{P_{10}}{f_p} = \frac{-P_{11}}{f_p + f_s} \qquad (7)$$

P_{11} is negative because P_{10} is positive by definition (it is the pump signal). We also know that $(f_p + f_s)$ is always positive, so the negative sign is associated with P_{11}.

For the second case (Manley-Rowe II):

$$\frac{P_{01}}{f_s} = \frac{-P_{11}}{f_p + f_s} \qquad (8)$$

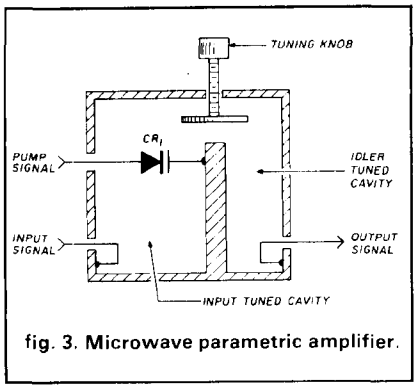


fig. 3. Microwave parametric amplifier.

Since P_{11} was defined as negative, by the same reasoning P_{01} is positive. Because P_{01} is positive, *signal power flows into the reactance*, and the circuit is stable. (A negative power term for the signal would denote instability.)

Either inductors or capacitors can be used as reactive elements in a parametric amplifier. In 1957 Suhl[5] and Weiss[6] proposed the use of ferromagnetic inductors in microwave amplifiers. Practical considerations favor the voltage variable capacitance diode ("varicap") as the reactance in parametric amplifiers. These devices work to frequencies above 20 GHz, and because they are voltage variable capacitors, make actual circuit implementation relatively easy. Varicaps operate in the reverse-bias zone of the I versus V curve, and tend to have low avalanche potentials. This ease of circuit implementation is gained at the

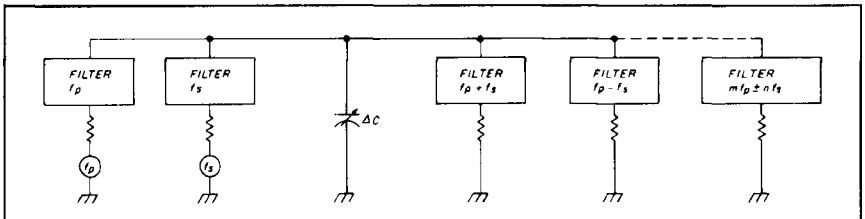


fig. 4. Equivalent circuit used to model Manley-Rowe relationships.

Solve the Manley-Rowe equations for this case:

$$I. \sum_{m,n} \frac{m\,P_{m,n}}{mf_p + nf_s} =$$

$$\frac{(1)\,(P_{10})}{(1)\,(f_p) + (0)\,(f_s)} + \frac{(0)\,(P_{01})}{(0)\,(f_p) + (1)\,(f_s)} +$$

$$\frac{(1)\,(P_{11})}{(1)\,(f_p) + (1)\,(f_s)} =$$

$$\frac{P_{10}}{f_p} + 0 + \frac{P_{11}}{f_p + f_s} = 0$$

$$\frac{P_{10}}{f_p} + \frac{P_{11}}{f_p + f_s} = 0$$

$$II. \sum_{m,n} \frac{n\,P_{m,n}}{mf_p + nf_s}$$

$$\frac{(0)\,(P_{10})}{(1)\,(f_p) + (0)\,(f_s)} + \frac{(1)\,(P_{01})}{(0)\,(f_p) + (1)\,(f_s)} +$$

$$\frac{(1)\,(P_{11})}{(1)\,(f_p) + (1)\,(f_s)} =$$

$$0 + \frac{P_{01}}{f_s} + \frac{P_{11}}{f_p + f_s} = 0$$

$$\frac{P_{01}}{f_s} + \frac{P_{11}}{f_p + f_s} = 0$$

expense of Johnson and other diode noise terms.

inductor-based superconductive parametric amplifiers

New superconductivity technology based on metallic ceramic materials has been reported. Researchers have achieved superconductivity states at relatively high temperatures (about 95 degrees K, with some promise of 225 degrees K).[7] The use of inductive reactances in parametric amplifiers is under reconsideration based on recent research. Several points are worth noting:

- Lower loss resonant circuits for signal, pump, and idler frequencies in conventional varicap-based parametric amplifiers (and perhaps lower achievable noise figures).
- Improved switchable inductors that operate at microwave frequencies, and make possible inductor-based parametric amplifiers.
- New forms of switchable energy storage devices that could replace present reactances in parametric amplifiers. Although one tends to think in traditional terms about inductive and capacitive reactances, perhaps a new type of reactance is possible. The strange behavior of superconductors with respect to magnetic fields may prove promising.[8]

A phenomenon noted as early as 1947 may be of interest in the latter case. Kinetic inductance produces inductance-like effects caused by the mass inertia of charge carriers in the material. In non-superconducting materials, ordinary magnetic inductance swamps the effects of kinetic inductance. In superconducting materials, however, magnetic inductance collapses leaving the kinetic variety.[9]

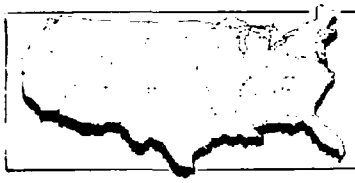
The conventional (varicap-based) parametric amplifiers are limited by their small dynamic range, due to the characteristics of the varicap diode used for the reactance. It may turn out that inductor-based devices will exhibit improved dynamic range.

One reason parametric amplifiers do not use superconductive technology is because the equipment needed to achieve the required near Absolute Zero temperature is expensive and large. This situation may change as progress is made in high temperature superconductivity.

references

1. M. Skolnik, *Radar Handbook*, McGraw-Hill, New York, 1970, pages 5-10 and M. Skolnik, *Introduction to Radar Systems*, McGraw-Hill, New York, 1980, figure 9.4, page 351.
2. S.Y. Liao, *Microwave Devices and Circuits Second Edition*, Prentice-Hall, Englewood Cliffs, New Jersey, 1985.
3. Ibid. See also Dr. James T. Coleman, *Microwave Devices*, Reston Publishing Company (Division of Prentice-Hall), Englewood Cliffs, New Jersey, 1982.
4. *ARRL VHF Manual*.
5. H. Suhl, "Proposal for a Ferromagnetic Amplifier in the Microwave Region," *Physics Review 106*, April 15, 1957, pages 384-385.
6. M.T. Weiss, "A Solid State Microwave Amplifier and Oscillator Using Ferrites," *Physics Review 107*, July 1957, page 317.
7. G. Maranto, "Superconductivity: Hope vs. Reality," *Discover* August 1987, pages 22-32.
8. Ibid.
9. *IEEE Transactions on Magnetics*, March 1987. Entire issue is devoted to superconductivity.

ham radio

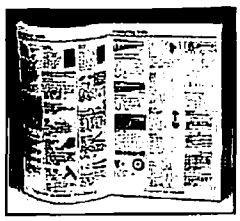


SAY YOU SAW IT IN ham radio magazine



FREE CATALOG!

Features Hard-to-Find Tools and Test Equipment



Jensen's new catalog features hard-to-find precision tools, tool kits, tool cases and test equipment used by ham radio operators, hobbyists, scientists, engineers, laboratories and government agencies. Call or write for your free copy today.

JENSEN® TOOLS INC.

Dept. HR
7815 S. 46th Street
Phoenix, AZ. 85044
(602) 968-6231

263

VHF-UHF POWER DIVIDERS



RF power dividers provides the best way to feed in-phase 2 and 4 antenna arrays to maximize system gain and at the same time reduce losses to a minimum. Covering 144 thru 1296 MHz, this series of VHF-UHF power dividers are premier RF devices designed for a long service life with low SWR and broad operating bandwidth.

Extruded aluminum body with a durable enamel finish in addition to silicon sealing at connector flanges results in a ruggedized unit for all array installations. Available with N-type connectors only, these units are unconditionally guaranteed for 2 years.

MODEL	CONFIG	PRICE
144-2P	(2 ports)	$51.00
144-4P	(4 ports)	$98.00
220-2P	(2 ports)	$50.00
220-4P	(4 ports)	$97.00
430-2P	(2 ports)	$48.00
430-4P	(4 ports)	$96.00
902-2P	(2 ports)	$48.00
902-4P	(4 ports)	$96.00
1296-2P	(2 ports)	$49.00
1296-4P	(4 ports)	$97.00

Suffix -N for N-F (SMA) add $3.00

STRIDSBERG ENGINEERING, CO.

P.O. Box 7973 • Shreveport, LA 71107 • USA
Phone (318) 865-0523

262

Texas Radio

BUGCATCHER MOBILE HF ANTENNA

NEW IMPROVED MODELS!



3-BAND COVERAGE - All Amateur, MARS, and CAP frequencies from 10 to 80 meters!

BANDSWITCHING - Switches instantly to pre-tuned frequencies on any band!

HIGH-Q RESONATOR - High-Q air inductor provides maximum efficiency on all bands!

FUNCTIONAL DESIGN - Provides low wind loading, easier tuning, and more pleasing appearance! Rugged construction for long life and reliability! New fold-over features!

300 WATT CAPACITY - Conservative rating!

COMPLETE ANTENNA - READY TO MOUNT

PRICE $74.95

1000 WATT MODEL AVAILABLE - $84.95

Add 5% for shipping in lower 48.

SASE for Product Info

TEXAS RADIO PRODUCTS
5 East Upshaw Temple, Texas 76501
(817) 771-1188

261

VHF/UHF WORLD

Joe Reisert W1JR

microwave components and terminology: part 1

From time to time I've featured microwave topics in this column. Most dealt with the present state of the art (SOA) but some gave a glimpse at older microwave components or terminologies.

The SOA changes so rapidly that many of the components once necessary for microwave systems have become extinct, been replaced, or moved upward in frequency. In light of this, I thought it would be a good time to discuss the basic microwave components of the past and present. This will make future developments easier to understand.

The subject of microwave components is extensive. Entire books have been written on single components such as waveguides. In this month's column, I will concentrate on microwave transmission lines and related components and build upon this information next month, in addition to describing some other common microwave features.

microwave transmission lines

A transmission line is a system of material boundaries forming a continuous path from one location to another. In radio communications from low frequencies through UHF this usually refers to a balanced line, coaxial cable, stripline, or microstrip transmission line. From UHF up through the microwave and millimeter wavelengths a waveguide or G-line is often used.

Transmission lines have many different properties. The most important for Amateurs are the impedance, insertion loss, power handling capacity, and velocity of propagation. These terms are described in detail in reference 1.

Balanced lines, often referred to as open wire, twin lead, or ladder lines, were the first type of transmision lines. They became popular when commercial television was introduced but have largely been replaced by coaxial cable.

coaxial transmission lines

Coaxial cable was invented in 1921 by Lloyd Espenschied and Herman A. Affel at the AT&T Engineering Labs in New York City. Nowadays it is by far the most common transmission line because it is easy to use, low cost, and operates over a wide frequency range. But, as frequency increases, so does the insertion loss. In general, the larger the diameter and the lower the dielectric loss (air is the lowest), the lower the insertion loss. Reference 1 gives information on typical insertion loss versus frequency.

Coaxial transmission lines normally consist of two conductors, often described as operating in the TEM (transverse electromagnetic mode or field pattern). This means that both the electric and magnetic fields are transverse or perpendicular to the axis of the line as shown in **fig. 1A**.

When spacing between the two elements in a coaxial transmission line exceeds one-half the operating wavelength or the circumference of the inside of the outer conductor exceeds one wavelength, energy can propagate down the transmission line in other than the desired mode. This is usually referred to as a higher order mode. The following formula quickly determines the maximum usable frequency below which higher order modes will *not* occur:

$$f_{co} = \frac{7.5}{\sqrt{\epsilon_r}\,(D+d)} \qquad (1)$$

Where f_{co} is in GHz, ϵ_r is the dielectric constant (air = 1.0), D is the inside diameter of the outer conductor, and d is the outside diameter of the inner conductor — both in inches. For example, a 50-ohm Teflon™ coax line, ϵ_r = 2.1, with D of 0.120 inches and d of 0.036 inches would be usable to at least 13.1 GHz.

In the last two decades, there has been much research and development in the field of coaxial transmission lines. Improved coaxial cables are smaller, more precise in impedance characteristics, and have lower loss. There are now commercial coax transmission lines that operate beyond 20 GHz.

Two of the most common microwave coax types used by Amateurs are the semi-rigid 0.141 and 0.085 inch outside diameter Teflon dielectric

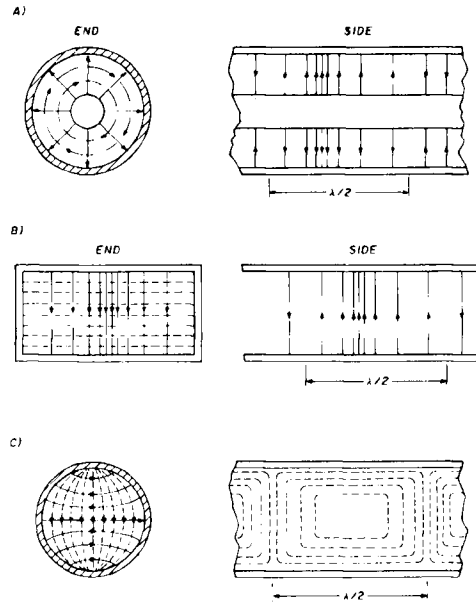


fig. 1. Typical field patterns present in (A) a coaxial transmission line operating in the TEM mode, (B) a rectangular waveguide operating in the TE_{10} mode, and (C) circular waveguide operating in the TE_{11} mode. The solid lines are the electric fields and the dashed lines are the magnetic lines.

50-ohm coax that manufacturers claim can operate to 30 and 55 GHz, respectively. Attenuation at 20 GHz is typically 60 and 100 dB per 100 feet for the two cables, respectively.

microwave strip transmission lines

The concept of strip-type transmission lines was discovered during World War II, and in the mid-1950s the first practical designs were introduced as "Tri-Plate".[2] These first strip transmission lines were a balanced structure with a "sandwich" construction and operated in the TEM mode similar to coaxial transmission line.[1]

Microstrip, a sort of open-faced sandwich version of stripline', followed and is widely used well into the microwave region. Glass PCB, G-10, can be used but is lossy at microwave frequencies. Lower loss dielectrics like Teflon-impregnated glass laminates and low-loss ceramics are available as are new types of structures — fin-line and suspended substrate, to name two.

waveguides

When you think of microwaves, what probably comes to mind are those bulky waveguides and waveguide components. In the "good old days", microwave engineers were often referred to as "plumbers" because they worked mainly with waveguides and other materials that resembled pipes and plumbing.

The practical uses of waveguides as transmission lines were discovered independently and almost simultaneously by W.L. Barrow and G.C. Southworth in 1936.[3,4] The breakthrough was one of many making radar and microwaves possible. Waveguide transmission lines have been used at frequencies below 200 MHz to well above 150 GHz!

There are four basic waveguide cross-sectional geometries: rectangular, square, elliptical, and circular. Each type has specific electrical properties and preferred usage.

Rectangular waveguide is probably the most common since it has the widest operating bandwidth. Its width is usually twice its height (see **fig. 2A**).

Square waveguide shown in **fig. 2B** is sometimes used in applications like dual polarized feeds and horns. However, since its height and width are the same and there is mode isolation, it is difficult to use.

Elliptical waveguide (**fig. 2C**) is often used where flexible runs are required — especially if it is corrugated and the run to be used is between 1.9 and 15 GHz. It is usually easier to install than rectangular waveguide but does have somewhat higher attenuation.

Circular waveguide (**fig. 2D**) has very low attenuation — sometimes only half that of rectangular waveguide — so it is often used on long, straight vertical or horizontal runs. Its circular nature allows two orthogonal modes to be propagated simultaneously, but this same circular symmetry can cause the polarization to rotate as the wave travels down the guide.

waveguide modes

A waveguide is a transmission line

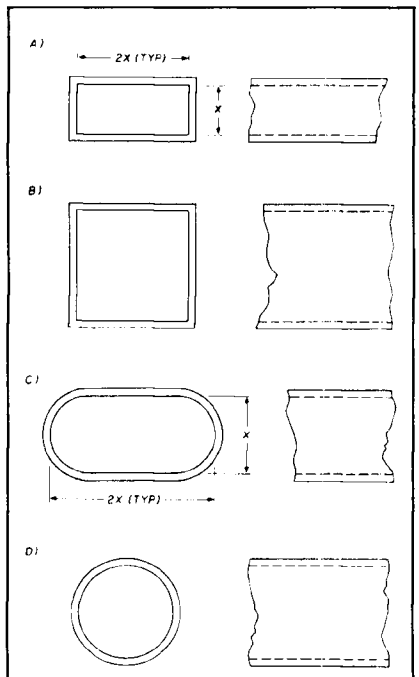


fig. 2. Common waveguide geometries. (A) Rectangular, (B) square, (C) elliptical, (D) circular.

where the wave propagation is not in TEM mode form. Waveguides appear to be simply a hollow tube with walls acting as a single conductor. Therefore, their operation is quite different from coaxial lines. Waveguides are mostly used as transmission lines but have other uses; these will be discussed in next month's column.

Waveguide transmission lines usually operate in a TE (transverse electric) mode in which the electric field is always transverse to the direction of propagation and transverse to the axis of the waveguide at all locations. Waveguides sometimes operate in the TM (transverse magnetic) mode in which the magnetic fields are everywhere transverse to the axis of the waveguide.

Unlike coaxial transmission lines which are not sensitive and can usually be operated from dc up to their cutoff frequency, waveguides are very frequency sensitive. Each geometry has a different cutoff wavelength or minimum frequency that can be propagated and below which the insertion loss is very high.

If the operating frequency is higher than some critical value determined by the dimensions and the geometry of the guide, the wave will propagate down it with low attenuation. If the wavelength is greater than this cutoff value, the waves in the waveguide die out rapidly in amplitude even if the material in the walls of the guide has infinite conductivity.

The mode for which the cutoff wavelength is greatest is the dominant mode (desired mode for transmission lines), since it has the least insertion loss. In a rectangular waveguide, it is often referred to as the TE_{10} mode.

The subscript "1" means that the field distribution in the direction of the long (cross-sectional) side of the waveguide contains one-half cycle of variation. The subscript "0" indicates that there is no variation in either the electric or magnetic field strength in the direction of the short side of the guide. The TE_{10} field pattern in a rectangular waveguide is shown in **fig. 1B**.

The width of a rectangular waveguide at the cutoff frequency is approximately half that of the free space wavelength. For example, the free space wavelength at 2.3 GHz is approximately 5.123 inches. Therefore, the width of a rectangular waveguide at this frequency must be at least 2.561 inches.

For minimum loss it is best to operate in the dominant mode, which is about 25 percent higher in frequency. Here the optimum width of a rectangular waveguide at 2.3 GHz would be 25 percent wider, or about 3.2 inches.

The dominant mode in a circular waveguide is the TE_{11} mode. **Figure 1C** shows its field pattern. Cutoff frequencies are different for circular and rectangular waveguides. The circular waveguides also have modes that are closer in frequency than those of rectangular waveguides so they have narrower mode-free bandwidth.

In general, the diameter of a circular waveguide needs to be slightly larger than the width of an equivalent rectangular waveguide to work at the same frequency. See reference 5 for additional design information for circular waveguides.

The impedance of a coaxial line is constant. In waveguides, impedance changes with size, mode, and frequency and is not easy to determine. If operating in the dominant mode in rectangular waveguide, the impedance is generally in the 350-to-600 ohm region.

Because waveguides are specifically intended for high frequency operation, the conductivity of the walls is very important and plating is usually used. The plating need not be thick since the skin depth is shallow — often less than 0.001 inches above 1.0 GHz.

Table 1 shows the resistivity and relative conductivity of some commonly used waveguide materials and plating. Copper and silver-plated copper are preferred.

Waveguides have standards and a part numbering system just like coaxial cables. See **table 2** for some of the standard rectangular waveguide types and their important physical and frequency characteristics.

Amateurs often use waveguides on the microwave bands. They cost little on the surplus market and have low loss, especially when used for antenna feed systems. Compared to coax, the loss of WR-90 waveguide is 4.5 to 6.5 dB per 100 feet over its operational frequency range of 8.2 to 12.4 GHz. A more complete list of the stan-

Table 1. Resistivity and relative attenuation of some common metals or platings used in transmission lines at RF frequencies.

Metal	Resistivity (ohms – cm × 10^{-6})	Attenuation (relative to copper)
Aluminum	2.62	1.23
Brass (66 Cu 34 Zn)	3.9	1.5
Copper (commercial annealed)	1.7241	1
Gold	2.44	1.19
Silver	1.62	0.97
Steel (stainless)	90	7.23

Table 2. Rectangular waveguide characteristics.

EIA Waveguide designation	Outside width (inches)	Outside height (inches)	Wall thickness (inches)	Frequency range (GHz)
WR-229	2.418	1.273	0.064	3.3-4.90
WR-187	2.000	1.000	0.064	3.95-5.85
WR-159	1.718	0.923	0.064	4.9-7.05
WR-90	1.000	0.500	0.050	8.2-12.4
WR-75	0.850	0.475	0.050	10.0-15.0
WR-42	0.500	0.250	0.040	18-26.5

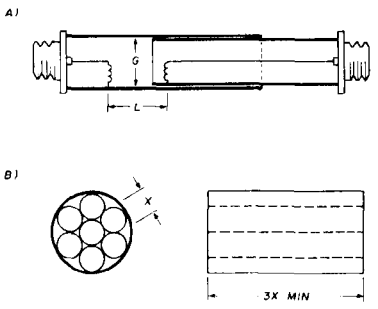


fig. 3. Typical waveguide beyond cutoff applications. (A) Waveguide beyond cutoff for attenuating a frequency well below the cutoff frequency, (B) the air exit system used on a high-power rf amplifier to prevent rf radiation.

dard waveguide types is found in reference 6.

G-lines

The G-line, invented in 1950 by the late Georg Goubau, is a single conductor surface-wave transmission line that suits the microwave frequencies, but until recently it hasn't been popular. Basically, the G-line is a single wire feedline with cone-like "launchers" at each end. Warren Weldon, W5DFU, has done a lot of work on this type of transmission line and has several operational low-loss lines in use on the microwave frequencies.[1] Perhaps more Amateurs will try his techniques and add G-line to their arsenal.

waveguides beyond cutoff

Although waveguides are most often used as transmission lines in the dominant mode, they can be used in the cutoff mode as RF attenuators at lower frequencies (see **fig. 3A**). Calculate the attenuation below the cutoff region in a rectangular waveguide using **eqn. 2**:

$A = 27 (L/G)$

where A is the attenuation in dB, L is the length of the guide, and G is the width, in the same units. For circular waveguide, use **eqn.3**:

$A = 32 (L/G)$

where L is the length and G is the diameter of the guide in the same units.

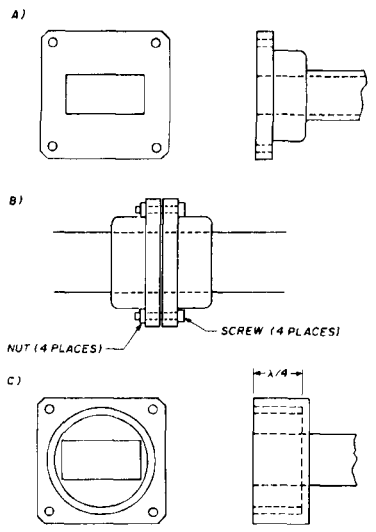


fig. 4. Typical waveguide flanges that are used in place of connectors on waveguides. (A) Typical flange, (B) two waveguides joined together with flanges, (C) a choke flange to decrease rf loss and impedance discontinuities.

Attenuation is a linear function and not frequency sensitive if operated sufficiently below the cutoff frequency. For example, a circular waveguide 0.5 inches in diameter and 0.5 inches long will have an attenuation of approximately 32 dB and 96 dB at 1.5 inches. A simple and accurate mechanical attenuator can be designed. One example is the output attenuator on signal generators like the Hewlett-Packard 608 (10-450 MHz).

Amateurs can also use waveguides beyond cutoff in high- power amplifiers at the entrance or exit for the air delivery system, where rf could leak and any restrictions will cause the tube to overheat.[7] Often a group of five to ten smaller tubes (e.g., 0.5 inch diameter) are grouped together to reduce the required length of a single large diameter tube, as shown in **fig. 3B**.

Today waveguides and microwaves are not always seen as synonymous and the SOA is changing so rapidly that coaxial components are starting to dominate the microwave field (at least up through 10 to 20 GHz). References 5 and 6 discuss microwave transmission lines and waveguide use in detail.

microwave connectors

Whether you use coaxial or waveguide transmission lines, you will probably need connectors. Special coax connectors have been developed for use as high as 34 GHz.[8]

Waveguides have connectors called "flanges" (**fig. 4A**). They are butting joints similar to plumbing unions and can be held together with ordinary machine screws as shown in **fig. 4B**. Sometimes these flanges do not join perfectly, causing rf leaks or impedance discontinuities. To prevent this, "choke" flanges with quarter-wavelength slots like those in **fig. 4C** have been developed.

transitions and junctions

Sometimes it's necessary to connect one waveguide size to another, just as you may interconnect an RG-8/U with an RG-17/U coax cable through a coax adapter. You might also want to change from a rectangular to a circular waveguide, or from a waveguide to a coaxial line. You can accomplish this with a "transition" device.

When connecting waveguides of different sizes, remember they will each have different impedances. If you were to operate at only one frequency you could design a quarter-wavelength waveguide transformer; but this would require tight mechanical tolerances that are difficult to maintain at these frequencies.

For this reason, waveguides of different sizes with common frequency ranges are often joined through a tapered section or transition. It is also desirable to have a transition to interconnect a circular and rectangular waveguide. Typical transition is shown in **fig. 5A**.

For a smooth change with minimum impedance discontinuities, transitions should occur over at least a wavelength. Typical losses in commercial circular to rectangular waveguide transitions are 0.1 to 0.3 dB.

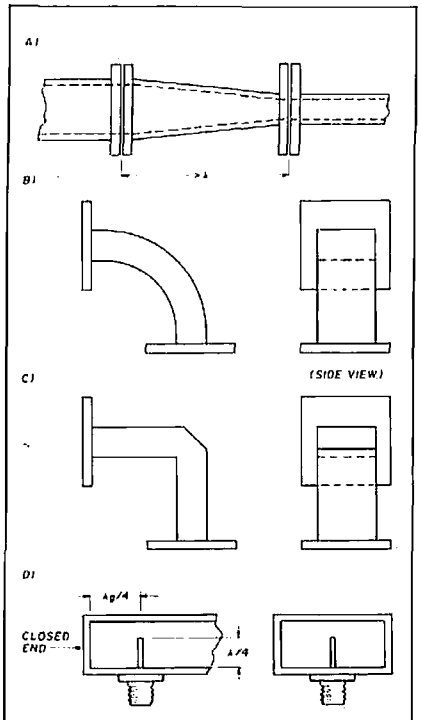


fig. 5. Typical waveguide transitions. (A) Two waveguides with different sizes but common frequency capability. (B) right-angle bend with gradual twist. (C) right-angle bend with mitred corner. (D) coax to waveguide transition using a voltage probe.

A right-angle bend is another common waveguide transition. An abrupt bend can be lossy, so smoothly bent waveguides (**fig. 5B**) or an abrupt bend with a mitered corner (**fig. 5C**) are used.

Sometimes it is desirable to connect a coaxial device to a waveguide section and vice versa. It is referred to as a waveguide-to-coax adapter and the impedance within the waveguide may be difficult to determine.

A coax-to-waveguide transition can be done with a voltage or a current probe inserted near the end of a shorted waveguide. The most common technique is the voltage probe which puts a quarter-wavelength "probe" into the closed end of a waveguide as shown in **fig. 5D**. This type of transition is often found at flea markets.

summary

This month's topic was microwave transmission lines and waveguides. The discussion concludes in next month's column, which will concentrate on other microwave components and terminology.

new VHF records

For some time now EME activity on 6 meters has been limited to a few energetic Amateurs who "think big". That is rapidly changing. I just heard that there is a new 6-meter EME DX record. On November 15, 1987 Ray Rector, WA4NJP, (EM84) worked Jim Treybig, W6JKV, (CM87) for an approximate distance of 2145 miles (3451 km). I hope to have more details in next month's column. Congratulations, Ray and Jim.

important VHF/UHF events:

March 16	*EME perigee*
March 18	*New moon (eclipse of the sun)*
March 21	*+2 weeks. Optimum time for TE propagation*
April 11	*ARRL 144-MHz Spring Sprint Contest (Monday evening local)*
April 13	*EME perigee*
April 16	*New moon*
April 19	*ARRL 220-MHz Spring Sprint Contest (Tuesday evening local)*
April 21	*Predicted peak of the Lyrids meteor shower at 1730 UTC*
April 27	*ARRL 432-MHz Spring Sprint Contest (Wednesday evening local)*
April 29-30	*Dayton Hamvention*
May 1	

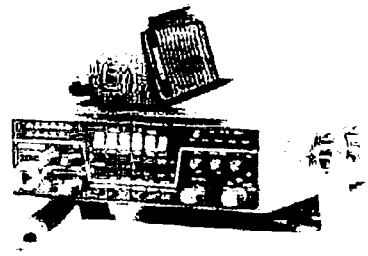
references

1. Joe Reisert, W1JR, "Transmission Lines," *ham radio*, October 1985, page 83.
2. Richard W. Peters et al, "Handbook of TRI-PLATE Microwave Components," Copyright 1956 by Sanders Associates, Inc., Nashua, New Hampshire
3. W.L. Barrow, "Transmission of Electromagnetic Waves in Hollow Tubes of Metal," Proceedings IRE, Volume 24, October 1936, page 1298
4. G.C. Southworth, "Hyper frequency Wave Guides General Considerations and Experimental Results," Bell System Technical Journal, Volume 15, October 1936, page 284.
5. Theodore Moreno, "Microwave Transmission Design Data," Dover Publishing, 1958.
6. "Reference Data for Radio Engineers," sixth edition, Howard Sams.
7. Joe Reisert, W1JR, "High Power Amplifiers: part 2," *ham radio*, February 1985, page 38.
8. Joe Reisert, W1JR, "RF Connectors: part I," *ham radio*, September 1986, page 77.
9. Joe Reisert, W1JR, "RF Connectors: part II," *ham radio*, October 1986, page 59.

ham radio

10 METER DX IS HOT!

AND YOU CAN WORK IT WITH THE NEW RANGER AR 3500



- Convenient, easy-to-use front panel controls
- All Mode operation
- Switchable noise blanker—highly effective on ignition noises
- 100 Hz per step
- Programmable band scanning
- Five selectable memory channels
- Split frequency operation
- Easy-to-read LED frequency display
- Available in outputs of 30 & 100 watts
- Microphone and power cord supplied

RECEIVER

Frequency Range: 28.0000-29.9999 MHz
Circuit Type: Superhet, dual conversion
Clarifier Range: ±500 Hz
Sensitivity: SSB & CW better than 0.3 μV for 10 dB S+N/N, FM better than 0.5 μV
Selectivity -6dB -60dB
SSB, CW 2.6 KHz 4.7 KHz
AM, FM 6.0 KHz 18 KHz

TRANSMITTER

Frequency Range: 28.0000-29.9999 MHz
Power Output: 30 watt Model: SSB—25 Watts, AM/FM—8 watts, CW—30 Watts
Input 12.5 VDC, 6A Max
Power Output: 100 watt Model: SSB—100 Watts, AM/FM—30 Watts, CW—150 Watts
Input 12.5 VDC, 25A Max

WARRANTY

Limited one year warranty by Clear Channel Corporation of Issaquah, WA.

AR3500-30W (Reg. 359) ..... Call Us
AR3500-100W (Reg. 449) ..... Call Us
Scan Mic & Mod installed $45.00
SP-1 Speech Processor 33.00
CW Bd. Auto break-in 39.95
3 Element Beam 26-30 MHz 89.50
Penetrator Mobile Ant. 44.95
RS-7A Pwr Sup for 30W 49.95
RS-35A Pwr Sup for 100W 134.95

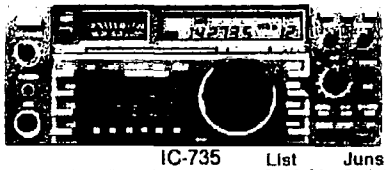
SEE YOU AT THE ORLANDO, CHARLOTTE & DAYTON HAMFESTS

Quantity Pricing Available Foreign Orders Accepted
Orders received by 1 PM PST shipped UPS same day.
COD VISA MC Next day UPS delivery available
ORDER DESK ONLY — NO TECHNICAL
(800) 854-1927
ORDER LINE and/or TECH HELP
(619) 744-0728
FAX (619) 744-1943

RF PARTS COMPANY
1320 Grand San Marcos
California 92069

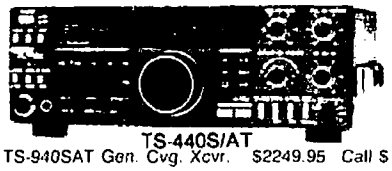
800-882-1343

ICOM



IC-735	List	Juns
IC-761 New Top of Line	2499.00	Call $
IC-735 Gen. Cvg. Xcvr	$999.00	Call $
IC-751A Gen. Cvg. Xcvr	1649.00	Call $
R7000 Gen. Cvg. Rcvr.	1099.00	Call $
R71A Gen. Cvg. Rcvr.	949.00	Call $
IC-28A/H FM Mobile 25w/45w	429/459	Call $
IC-37A FM Mobile 25w	499.00	Call $
IC-900 Super Multi-Band Mobile	589.00	Call $
IC-04AT UHF HT	449.00	Call $
IC-48A UHF 45w	459.00	Call $
IC-38A FM Mobile 25w	459.00	Call $
IC-02AT FM HT	399.00	Call $
IC-μ2AT Micro HT	329.00	Call $

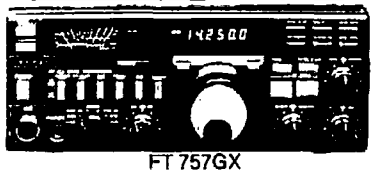
KENWOOD



TS-440S/AT

TS-940SAT Gen. Cvg. Xcvr.	$2249.95	Call $
TS-430S Gen. Cvg. Xcvr.	819.95	Call $
TS-711A All Mode Base 25w	899.95	Call $
TR-751A All Mode Mobile 25w	599.95	Call $
TS-440S/AT Gen. Cvg. Xcvr	1199.95	Call $
TM-2530A FM Mobile 25w	429.95	Call $
TM-2550A FM Mobile 45w	469.95	Call $
TM-2570A FM Mobile 70w	559.95	Call $
TH-205 AT, NEW 2m HT	259.95	Call $
TH-215A, 2m HT Has It All	349.95	Call $
TH21BT 2M HT	259.95	Call $
TH31BT 220 HT	269.95	Call $
TM-3530A FM 220 MHz 25w	449.95	Call $

YAESU

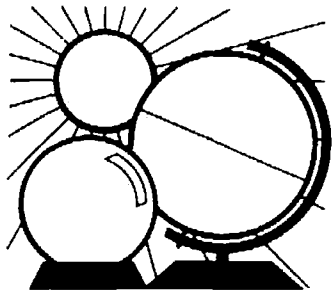


FT 757GX

FT-757 GX Gen. Cvg. Xcvr.	$995.00	Call $
FT-767 4 Band New	1895.00	Call $
FT-211 RH	459.95	Call $
FT-290R All Mode Portable	579.95	Call $
FT-23 R/TT Mini HT	299.95	Call $
FT-209RH RM Handheld 5w	359.95	Call $
FT-726R All Mode Xcvr	1095.95	Call $
FT-727R 2M/70CM HT	479.95	Call $
FT2700RH 2M/70CM 25w	599.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003



DX FORECASTER

Garth Stonehocker, KØRYW

the ultimate antipode DX

In our eternal search for the optimum propagation path and mode, one in particular — antipodal DX — has probably escaped our attention. The antipode is the farthest location on the earth from you. You can visualize this point by drawing a line from your location through the center of the earth to the opposite side of the world, or calculate it by taking the opposite latitude (40°S from 40°N) and subtract your longitude from 180° and switch west to east or vice versa. Now the question is: are any Radio Amateurs there?

what's special about your antipode?

All directions point to it, every great circle path from your location goes through it, and, at the antipode there are energy focusing effects enhancing signal strengths. Experiments have determined that the antipode reception area has a 300-mile radius before the signal diminishes by 12 dB. At greater distances, signal levels *rebuild* by 6 dB. This 6-dB range is equivalent to the cyclical signal variations that occur in sync with propagation mode changes.

The 6-dB circle perimeter is not fixed and its size can vary on a short (diurnal) and long term (yearly) basis much like any other geophysical parameter. Propagation experiments also show that reception occurs up to 50 percent more often at the antipode than at a location only 900 miles away. The operating frequency used must not exceed the MUF for the particular azimuth you choose. Avoid paths requiring the signal to cross the polar regions because of accompanying low MUFs, geomagnetic, and auroral signal absorption problems. Also avoid equatorial paths where the MUF is considerably higher than the operating frequency because the greatest daytime signal absorption is found in those directions. Just remember — many directions still point toward your antipode and one will be best for you.

last-minute forecast

The higher hf bands should peak (higher MUF) during the third and fourth weeks of March with increased solar flux levels *and* flare activity. These flares may cause geomagnetic field-ionospheric disturbances around the 17th and 26th. The solar wind particle count is expected to increase around the 6th as a result of thinner solar coronal. Excellent transequatorial openings should accompany these disturbances. Lower solar flux values expected during the first two weeks of the month with lower signal absorption will enhance daytime lower band DX (though not as good as a year ago). Evening/nighttime DX should be good except when local thunderstorm noise increases. Spring equinox occurs on March 20th at 0939 UTC. A full moon appears on the 3rd and will be at perigee on the 16th.

band-by-band summary

Ten, fifteen, and twenty meters will be open from morning to early evening almost daily in most areas of the world. Expect higher band openings to be shorter and closer to local noon. Transequatorial propagation on these

269

MARCH

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	4:00	20	40	20	10	15	12*	10	15	5:00	20	40	20	12*	15	10	10	15	6:00	7:00	20	40	20	12	15	10	10	20
0100	5:00	20	40	20	12	15	10	10	15	6:00	20	40	20	12	15	10	10	20	7:00	8:00	30	40	20	12	15	12	12	20
0200	6:00	20	40	20	12	15	10	10	20	7:00	20	40	20	15	15	12	10	20	8:00	9:00	30	40	20	15	15	12	12	30
0300	7:00	20	40	20	15	15	10	10	20	8:00	30	40	20	15	15	15*	12	30	9:00	10:00	40	40	20	15	15	15	15	30
0400	8:00	20	40	20	15	15	12	12	20	9:00	40	40	20	15	15	15	12	30	10:00	11:00	40	40	20	20	20	15	15	30
0500	9:00	30	40	20	20	15	12	12	30	10:00	40	40	20	20	20	15	15	30	11:00	12:00	40	40	20	20	20	20	20	40
0600	10:00	30	40	20	20	20	15	15	30	11:00	40	40	20	20	20	15	15	40	12:00	1:00	40	40	20	20	30	20	20	40
0700	11:00	40	40	20	20	30	15	15	30	12:00	40	40	20	20	30	20	20	40	1:00	2:00	40	40	20	20	30	20	20	40
0800	12:00	40	40	20	20	30	15	20	30	1:00	40	40	20	20	30	20	20	40	2:00	3:00	40	40	20	20	30	20	20	40
0900	1:00	40	40	30	20	30	20	20	40	2:00	40	40	30	20	30	20	20	40	3:00	4:00	40	20	20	20	30	20	20	40
1000	2:00	40	40	30	20	30	20	20	40	3:00	40	40	20	20	30	20	20	40	4:00	5:00	20	20	15	30	30	20	20	40
1100	3:00	40	40	30	20	30	20	20	40	4:00	30	30	15	20	30	20	20	40	5:00	6:00	20	20	15	20	30	20	30	30
1200	4:00	40	30	15	20	30	20	20	40	5:00	20	20	15	20	30	20	20	40	6:00	7:00	20	20	12	15	30	20	20	30
1300	5:00	40	20	15	20	30	20	20	40	6:00	20	20	12	20	30	20	20	40	7:00	8:00	20	20	10	15	20	20	20	40
1400	6:00	30	20	12	15	30	20	20	40	7:00	20	20	12	15	20	20	20	40	8:00	9:00	20	20	10	15	20	20	20	40
1500	7:00	30	20	12*	15	20	20	20	40	8:00	30	20	10	15	20	20	20	40	9:00	10:00	30	20	10	12	15	20	20	40
1600	8:00	40	20	10	12	20	30	20	40	9:00	30	20	10	12	15	30	30	40	10:00	11:00	30	20	10	12	15	30	20	40
1700	9:00	40	20	10	12	15	20	20	40	10:00	30	20	10	12	15	20	20	40	11:00	12:00	30	20	10	12	15	20	20	40
1800	10:00	40	20	10	12*	15	20	30	40	11:00	40	20	10	12*	15	20	20	40	12:00	1:00	40	20	12*	12*	15	20	20	40
1900	11:00	40	20	12	10	15	15	20	20	12:00	40	20	12*	10	15	15	15	30	1:00	2:00	40	20	12*	10	15	15	20	30
2000	12:00	40	20	12	10	15	15	15	20	1:00	40	30	12	10	15	15	15	20	2:00	3:00	40	20	12	10	15	15	15	20
2100	1:00	40	30	15	10	15	12	15	20	2:00	40	30	15	10	15	12	15	20	3:00	4:00	40	30	15	10	15	12	15	20
2200	2:00	40	30	15	10	15*	12	12	15	3:00	40	30	15	10	15	12	12	20	4:00	5:00	40	30	15	10	15	12	12	20
2300	3:00	20	30	15	10	15	12	12	15	4:00	40	30	15	10	15	12*	12	15	5:00	6:00	40	40	15	10	15	10	12*	20
		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next higher band for possible openings.

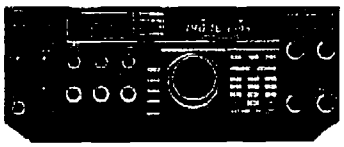
MADISON SHOPPER

CALL FOR ORDERS
1 (800) 231-3057
1-713-520-7300 OR 1-713-520-0550
TEXAS ORDERS CALL COLLECT
ALL ITEMS ARE GUARANTEED OR SALES PRICE REFUNDED

New Icom IC-781 — Trades wanted
Kenwood TH-215A TH-25AT — Trade in your old HT



Kenwood TS-140S Call
Kenwood TS-140S — Call for trade
New Kenwood TM-221A 45W mobile — Call
ICOM 28HFTM — Call



Icom 761 — Call

Yaesu 444D — $4.95
Astatic MC321 Carbide D104 — 12.00
Astatic D104C TUP-9 — 22.00

Icom 144 MHz — $3.95
Diamond 144 WB (146 MHz) — 39.00
Butternut HF6V 80-10 vertical — 175.00
Heathkit GC-144 — 149.95
KLM 16 Watt Class Super Accessories — Call Dave
KLM LT-144A — 109.00
HFW-8, M-2 44LBX — 1.79.00
G5-RV — 44.95

Diamond mobile whip glass — 49.95
New Larsen CM-450 CO — 5.00
Antenna 2M 5/8 Mag Mount Clamp — 25.00

Heath SA-2040 Preamplifier — 49.95
RG8/U — 95.00
Astron 50A 50A Switching Supply — 5.95
Transformer 120 Pri 1950 V 3A (Sec #18 Wire) — 9.00
Astron 45M Amp Case — 2.00

Yaesu FP-700 Speaker — 1.95
EC-611 Mobile — 2.00

GE 14-66B — 4.95
Astron 50A — 150.00
GE 12M6-7A — 2.00
MM-1 — 12.95
MM-6 — 12.95

APA PK-232 with new WX FAX — 299.00
Kantronics KPC-II — 149.00
AEA Packet Terminal — Call

USED EQUIPMENT

Always in stock used ham and CB equipment, manuals, and test equipment. Some models will be gone when you read this. Please check with us before ordering. Call us today!

Call for latest used gear
(800) 231-3057
Texas (800) 392-3067

Yaesu FT-757GX, FT-767GX, FT-726R, etc. Call

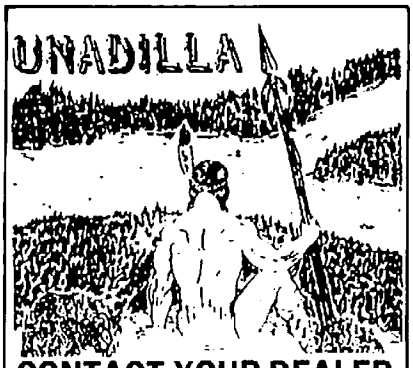
Panasonic KX-1124 Printer — 179.00

POLICIES

Minimum order $10.00. Master Card, VISA or C.O.D. All prices F.O.B. Houston, Texas. Prices subject to change without notice. Items subject to prior sale. Personal checks held 4 weeks before shipping. Texas residents please add 6 1/2% sales tax. Add shipping, handling & insurance. Allow additional time for personal checks, money orders, APO & FPO orders. Add 5% for Canada, Mexico, Alaska, Hawaii, PR, Virgin Islands, APO & FPO orders. Add 10% for all other countries. Minimum $5.00. Unauthorized returns will be refused. Returned items subject to restocking charge. Defective items must be returned within 15 days for replacement. Equipment shipped on a factory carton basis. Warranty is that of the manufacturer. Some items may be discontinued without notice. Some items may be limited in quantity. Prices may change without notice.

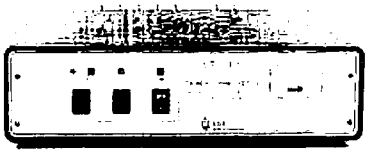
Bird and Belden products in stock. Call today. ↙ 273

MADISON
Electronics Supply
3621 FANNIN
HOUSTON, TEXAS 77004
MasterCard VISA



CONTACT YOUR DEALER
FOR MORE INFORMATION
Amateur Radio Baluns-
Traps-Remote Coaxial Switches
Or Write To:
UNADILLA DIV. of ANTENNA'S ETC.
P.O. Box 215 BV ANDOVER, MA. 01810
617-475-7831

↙ 272



SSB ELECTRONIC TRANSVERTERS & PREAMPLIFIERS

LI33S	902/144 Xvrtr 20W GaAsfet	$699
LI23S	1296/144 Xvrtr 10W GaAsfet	$599
MICRO 13	2304/144 Xvrtr 0.5W GaAsfet	$419
MICRO X	10.368/144 Xvrtr 200mw GaAsfet	$649
mgs products		
SP-2	144-148 Mhz RF switched preamp	$209
SP-70	430-440 Mhz RF switched preamp	$209
LI13S	2304/144 Xvrtr 5W GaAsfet	$599
other items		
144-028	144 Mhz transverter 25W 28 or 50 IF	$229
1220/28	220 Mhz transverter 15W 28 or 50 IF	$249
PA 33200	902 Mhz 200 Watt PA	$549
PA 23150	1296 Mhz 150 Watt PA	$469
PA 23200	1296 Mhz 200 Watt water cooled PA	$299
PA 1325	2304 Mhz 25 Watt PA	$439
HI 400	High Power Relay 2 KW at 144 Mhz	$139
HI 2000/6	Relay 2 KW at 100 Mhz 400 W at 6 Ghz	$219

Factory Authorized Dealer for SSB Electronics for North America

TRANSVERTERS UNLIMITED
BOX 6286 STATION A
TORONTO, ONTARIO
CANADA M5W 1P3
(416) 759 5562

TRANSVERTERS UNLIMITED (US)
P.O. BOX 178
NEW BOSTON, NH 03070
(603) 547-2213

↙ 271

Half-Square QRV-DX Monobanders

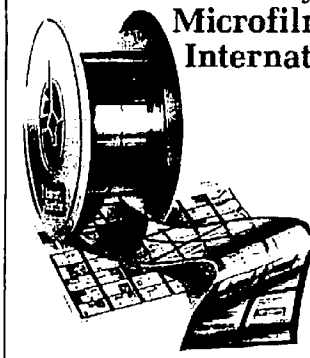
Work DX with No Tower and No Amplifier.
Cut noise, cut near sigs, build DX sigs, kill QRM.

10 Meters	15 Meters	20 Meters	30 Meters
$29.95	$39.95	$49.95	$59.95

Broadside Pattern, Low Profile, Coax Feed, Ready to Use
Highest DX Gain per Dollar
To order add $5 Postage & Handling and call or write:
1971 North Oak Lane
Provo, UT 84604-2138
AntennasWest
(801) 374-1084

↙ 270

This publication is available in microform from University Microfilms International.



Please send information about these titles.

Name
Company/Institution
Address
City
State Zip
Phone ( )

Call toll-free 800-521-3044. In Michigan, Alaska and Hawaii call collect 313-761-4700. Or mail inquiry to: University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106

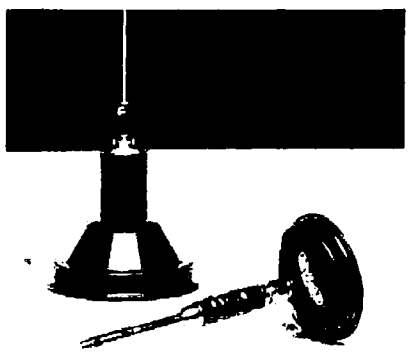
bands is likely to be toward evening during times of high solar flux and disturbed geomagnetic field conditions.

Thirty and forty meters will be useful almost 24 hours a day. Daytime conditions will resemble those on 20 meters, but skip and signal strength may decrease during midday on days with high solar flux values. Look for good nighttime use — except after days of very high MUF (solar flux) conditions. Usable distances on these bands should be somewhat greater than that achieved on 80 at night.

Eighty and one-sixty meters, the nighttime DXer's bands, will open just before sunset and last until sunrise on the path of interest. Except for daytime short-skip signal strengths, high solar flux values have little effect. Geomagnetic disturbances, more evident at the equinoctial periods, cause signal attenuation and fading on polar paths. Noise increases noticeably on these lower frequency bands now and in the coming months. Please remember the DX windows of 3790 to 3800, 1825 to 1830, and 1850 to 1855 kHz.

ham radio

NEW products



magnetic mount antennas

Hustler, Inc. announces two new magnetic mount antennas. Rated at 100 watts, the RX series consists of a 5/8 wave, 3.4-dB antenna on a magnet mount that withstands speeds up to 75 mph. The RX-2 (2 meter) and the RX-220 (220 MHz) are chrome with a black mount and coil cover. The suggested list price for both models is $19.95. The RX series is available in all-black versions (models RX-2B and RX-220B), each with a list price of $24.95.

The FX series, rated at 200 watts, is a 5/8 wave, 3.4-dB antenna on a heavy duty magnet mount which holds at speeds in excess of 100 mph. The FX-2 (2 meter) and the FX-220 (220 MHz) list for $24.96 each. All-black versions of the FX series are available as models FX-2B and FX220B priced at $29.95 each.

For information contact Hustler, Inc., One New-Tronics Place, Mineral Wells, Texas 76067.

Circle #301 on Reader Service Card.

high-power linear amplifier

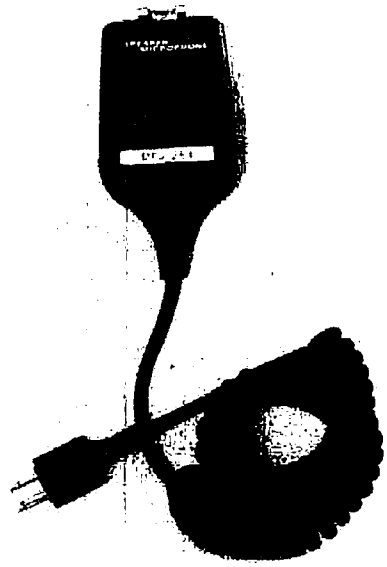
The HL 180V is a high power linear amplifier designed for 144-MHz band and all-mode operation. It provides a maximum output power of 170 watts. You can operate the amplifier with 3/10/25 watt output transceivers, as it will automatically select the incoming drive level. The LED power level indicator enables you to monitor the output power level at all times. Overvoltage protection circuit prevents the rf power transistors from being damaged. Remote control lead wires are incorporated to enable a smooth and instant changeover especially on SSB.

The THL model HL 180V is now available at your local ENCOMM dealer. Suggested list price is $359.95. For further information contact ENCOMM, Inc., 1506 Capital Avenue, Plano, Texas 75074.

Circle #302 on Reader Service Card.

MFJ speaker/mic for handhelds

The new MFJ speaker/mic with its lapel/pocket clip, lets you carry your handheld easily. It has a lightweight retractable cord and a con-



nector that fits ICOM and Yaesu handhelds. It features clean audio on both transmit and receive.

Available from MFJ dealers or direct from the company, the MFJ-284 retails for $24.95 and has a one-year unconditional warranty.

For more information contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #303 on Reader Service Card.

novice welcome

Gordon West Radio School has a Novice welcome package containing literature sheets, rebate coupons, and in-store discount offers from 30 Amatuer Radio equipment manufacturers and accessory suppliers, and five dealers.



Included are ICOM, Kenwood, and Yaesu gift certificates worth up to $25 each towards the purchase of new radio gear and free magazine issue certificates with subscription discounts. There are catalogs from Amateur Radio accessory manufacturers and "tip sheets" from manufacturers on how to set up a beginner Novice voice-class station sent with each beginner course.

The 21-day Novice course includes two stereo code-learning cassettes and West's 112-page Novice book. Priced at $19.95 (plus $2.50 postage and handling), the course materials include: FCC Form 610, a frequency reference chart, laminated world map, and a sample Novice exam package.

Students who pass any upgrade examination or Novice entry-level exam receive equipment discount coupons from ICOM, Yaesu, and Kenwood. Anyone who passes the exams within 120 days, using our materials, may write and receive radio rebate rewards, an FCC license holder, certificate of course completion, certificate for a free Amateur Radio magazine, and other coupons.

For more information, write to Gordon West Radio School, 2414 College Drive, Costa Mesa, California 92626.

Circle #304 on Reader Service Card.

Heathkit catalog

The Heathkit H-386 Desktop Computer, an 80386-based computer that operates two to three times faster than a PC/AT, appears in the latest Heathkit Catalog. Also featured is the Zenith Data Systems Flat Tension Mask Color Monitor with a flat screen and VGA compatibility.



The most powerful kit computer offered today, the H-386 provides graphics capabilities using a 31 kHz video card that automatically emulates EGA, CGA, MDA, and Hercules graphics, depending on what video-mode software requires. The standard 1 megabyte of RAM can be expanded up to 16 megabytes. The kit is easy to build and includes the H-386 with 1 megabyte of RAM, the VGA video card, and one 1.2 megabyte 5-1/4 inch disk drive for $3349.95.

2x4Z BASE REPEATER ANTENNA

THE HIGHEST GAIN DUAL BAND BASE/REPEATER ANTENNA

HIGH POWER 200 WATTS

CENTER FREQUENCY
146.500 MHz
446.500 MHz

GAIN:
VHF - 8.2dB
UHF - 11.5dB
VSWR - 1.-1.2 or less

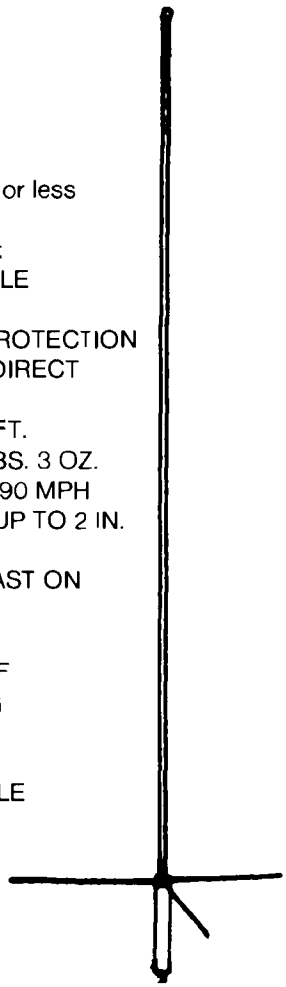
CONNECTOR:
N TYPE FEMALE

LIGHTNING PROTECTION
GROUNDED DIRECT

LENGTH: 16 FT.
WEIGHT: 5 LBS. 3 OZ.
WIND LOAD: 90 MPH
MOUNTING: UP TO 2 IN. MAST
CAN SIMULCAST ON BOTH BANDS

WATERPROOF CONNECTING JOINTS

UPS SHIPPABLE



AMATEUR SPECIAL

NCG CO.
NCG
1275 NORTH GROVE ST.
ANAHEIM, CALIF. 92806
(714) 630-4541
CABLE: NATCOLGLZ
FAX (714) 630-7024

✓ 277

BLACK DACRON® POLYESTER ANTENNA ROPE

- UV-PROTECTED
- HIGH ABRASION RESISTANCE
- REQUIRES NO EXPENSIVE POTTING HEADS
- EASY TO TIE & UNTIE KNOTS
- EASY TO CUT WITH OUR HOT KNIFE
- SIZES: 3/32" 3/16" 5/16"
- SATISFIED CUSTOMERS DECLARE EXCELLENCE THROUGHOUT U.S.A.

LET US INTRODUCE OUR DACRON® ROPE TO YOU • SEND YOUR NAME AND ADDRESS AND WE'LL SEND YOU FREE SAMPLES OF EACH SIZE AND COMPLETE ORDERING INFORMATION.
Dealer Inquiries Invited

synthetic textiles, inc.
2472 EASTMAN AVE., BUILDING 21
VENTURA, CALIFORNIA 93003
(805) 658-7903

✓ 276

THE RF CONNECTION

"SPECIALIST IN RF CONNECTORS AND COAX"

Part No.	Description	Price
321-11064-3	BNC 2 PST 28 volt coaxial relay, Amphenol Insertion loss: 0 to 0.75GHz, 0.10dB Power rating: 0 to 0.5GHz, 100 watts CW, 2 kw peak Isolation: 0.1 GHz/45db, 0.2 GHz/40db, 0.4 GHz/35db	$25 used tested
83-822	PL-259 Teflon, Amphenol	1.50
PL-259/ST	UHF Male Silver Teflon, USA	1.50
UG-21D/U	N Male RG-8, 213, 214, Amphenol	2.95
UG-21B/U	N Male RG-8, 213, 214, Kings	4.00
9913/PIN	N Male Pin for 9913, 9086, 8214 fits UG-21D/U & UG-21B/U N's	1.50
UG-21D/9913	N Male for RG-8 with 9913 Pin	3.95
UG-21B/9913	N Male for RG-8 with 9913 Pin	4.75
UG-146/U	N Male to SO-239, Teflon USA	5.00
UG-83/U	Female to SO-239, Teflon USA	5.00

"THIS LIST REPRESENTS ONLY A FRACTION OF OUR HUGE INVENTORY"

THE R.F. CONNECTION
213 North Frederick Ave. #11
Gaithersburg, MD 20877

(301) 840-5477
VISA/MASTERCARD: Add 4%
Prices Do Not Include Shipping

✓ 275

1988 CALL DIRECTORY
(on microfiche)

Call Directory	$8
Name Index	$8
Geographic Index	$8

All three — $20 Shipping per order $3

BUCKMASTER PUBLISHING
Mineral, Virginia 23117
703-894-5777

✓ 274



The ZCM-1490 Flat Tension Mask (14 inch diagonal) Monitor has true color at higher intensities with more contrast, brighter colors, and less glare than conventional round monitor cathode ray tubes.

The Robot Arm Trainer, a flexible, multijointed robotic arm, is also new. Controlled by an 8-bit microprocessor, the ETS-19-32 Trainer can be programmed through its attached teaching pendant, and connected to a computer through an RS-232 serial port. It features five axes of motion, and a patented sense-of-touch gripper programable for specific amounts of force. Six closed-loop DC servo motors provide smooth, accurate movement, and menu-driven software allows command option selections.

For a free catalog, write Heath Company, Department 350-030, Benton Harbor, Michigan 49022. In Canada, write Heath Company, Dept. 3100, 1020 Islington Ave., Toronto, Ontario M8Z 5Z3.

Circle #305 on Reader Service Card.

YA-1 low pass filter

Bencher's Low Pass Filter can help Amateurs active on high frequency bands resolve television interference problems. The YA-1 filter has a minimum attenuation of 80 dB or better in independent lab tests for harmonic radiation in channel 2 and higher.

For details write Bencher, Inc., 333 West Lake Street, Chicago, Illinois 60606.

Circle #306 on Reader Service Card.

"DCPS" switcher power supply for the C-64

Engineering Consulting announces a new power supply for Commodore 64 computers allowing operation directly from 12 volts dc or batteries. The power supply provides emergency backup and solar power operation.

The "DCPS" delivers 9 volts ac at exactly 60 Hz and 5 volts at up to 2 amps. A crystal controlled time base is used to divide a 3.58-MHz crystal to 60 Hz so an accurate clock is generated for the computer's internal timers. The 5 volts dc is provided by a state-of-the-art switcher at 75 percent efficiency.

The power supply is cable ready and plugs right into the C-64. For additional current reduction a jumper can be installed bypassing the internal 5-volt regulator, and the "DCPS" will provide the entire 5-volt requirement. This modification lets the C-64 operate with a current drain of 1 amp from the 12 volt battery.

The "DCPS" is available from Engineering Consulting, 583 Candlewood Street, Brea, California 92621 for $119.95 plus $4.00 shipping.

ELMER'S NOTEBOOK

Tom McMullen, W1SL

transmission lines

Transmission lines are a vital part of any Amateur station, but often the most mysterious component (and most misunderstood as well) used in setting up a station. This month's notebook looks at how transmission lines are put together and what they do. Perhaps you'll feel a bit more at ease in a discussion of lines and their advantages and faults after reading it.

why a transmission line?

There was a time when transmission lines were not widely used by Amateurs — when TV didn't exist, houses (and neighbors) were not packed together on postage stamp sized lots, and those who happened to hear an Amateur on their Broadcast-Band sets were more interested in eavesdropping than complaining.

In the interest of simplicity and economy, the end of a length of wire was simply run into the ham shack and tapped onto the power amplifier plate-tuning circuit through a suitable capacitor. The tap was moved along the turns of the coil until the proper plate current at resonance was obtained, indicating that the amplifier was properly loaded and providing power to the antenna.

This worked well -- the antenna radiated (and the radiation included several harmonics as well as the fundamental signal), QSOs were made, and everyone was happy. The fact that all of the wire radiated -- even the portion that was inside the ham shack — didn't particularly bother anyone. An occasional "hot" key or microphone gave a slight tingle or warm sensation to the operator, and sometimes the lights flickered a bit from induced rf in the power lines, but that was part of the mystique of being an Amateur.

Those who were more interested in doing things right knew they would get better results by placing the antenna high, away from power lines, telephone lines, and other metal objects that could intercept the energy being sent toward the horizon for a distant station to hear. What was needed was a means of getting the energy across that gap between the output of the transmitter in the shack and the feedpoint of the antenna many feet in the air. The answer was a transmission line.

Early transmission lines were handmade, open-wire lines with fairly wide spacing (often 6 or 8 inches between wires). The ingenuity of hams in adapting materials for use as insulating spacers was just as great then as it is now: glass rods, porcelain insulators, and wood dowels that had been boiled in paraffin (wax) were common materials. Today, almost any type of transmission line you need can be found at electronics parts stores or Amateur conventions and flea markets. Still, there are those who take pride in constructing an open-wire line of parallel No. 14 wire supported by plastic hair curlers or 35-mm film can lids.

open-wire lines

Figure 1A shows the evolution of a single-wire antenna (or feeder for an

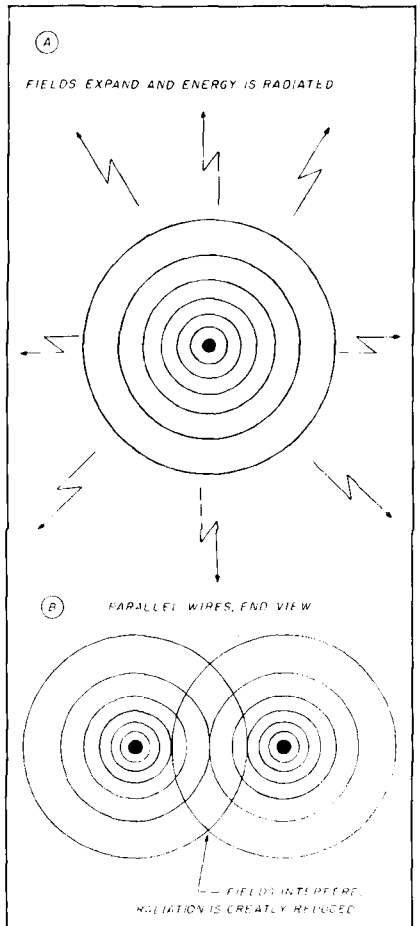


fig. 1. Single versus balanced wire line. A single wire, used as a feeder, radiates energy the same way as an antenna. Another parallel wire completes a circuit with current flow going in the opposite direction. The opposing electromagnetic fields cancel each other, so that almost no radiation takes place. Thus, the energy is conducted to the antenna to be radiated.

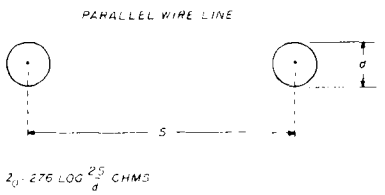


fig. 2. The impedance of open-line (parallel wire) transmission line is determined by the center-to-center spacing of the wires and its diameter. Any material between the wires other than air will lower the impedance.

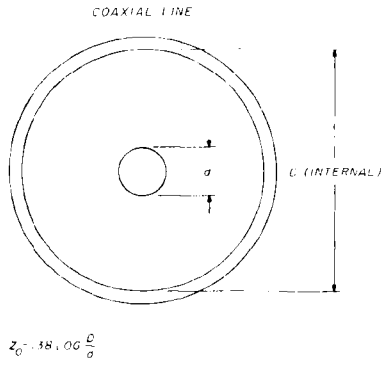


fig. 3. Coaxial cable impedance is determined by the diameter of the center conductor, the inside diameter of the outer conductor, and the distance and dielectric between them.

end-fed long wire) into a parallel-wire transmission line (**fig. 1B**). The line works because the fields from instantaneous current flow cancel each other. This means that the line does not radiate any significant amount of energy from your transmitter; it is being passed along to the antenna where it's radiated into space well above wires, TV sets, and telephones.

All transmission lines have a characteristic impedance, referred to as "Z", or "Z_0". This is important because all parts of the system must be matched, as discussed in last month's notebook. The impedance of a line is determined by the diameter of the wires and the space between them, as shown in **fig. 2**. The formula given is accurate for wires that have mostly air between them — a few supporting spacers will not change the impedance enough to worry about. The air between the wires is called the "dielectric", just as it is when referring to air between the plates of a capacitor.

Any insulating material other than air, if present in large amounts, will significantly change the impedance of the line — usually to a lower value. If you measure the wire diameter and spacing of common 300-ohm TV twin lead, and use the impedance formula in **fig. 2**, you'll get the wrong answer. The manufacturer knows what the effect of his dielectric is, and adjusts the spacing of the wires accordingly.

Two types of open-wire lines are 450- and 300-ohm "ladder line", once widely used for low-loss TV reception. This is the lowest loss transmission line you can get for an Amateur hf band installation and requires some care when putting it to use. Sharp bends are a no-no, and it should not be closer than 6 or 8 inches to any metal: gutter pipes, eaves, aluminum siding, window frames, or other wires. It should be stretched tight and supported on insulators so it will not swing in the wind or twist and short-circuit.

Open-wire lines need a matching device or transformer of some sort between the line and the transmitter (and sometimes between the line and the antenna). For transforming from coaxial cable to open-wire line, a balun is often used. This device gets its name from the operation it performs — adapting a **bal**anced line to an **un**balanced one. The function of a balun is merely this - it does not match impedances.

There are different types of baluns: 50-to-300 ohm, 50-to-50 ohm, and 75-to-300 ohm are the most common. A typical installation might require a 50- or 75-ohm transmitter output to be adapted to 300-ohm open-wire line; a 75-to-300 ohm balun will do the job. Another typical use is at the center of a half-wave dipole for 80 meters — a 50-to-50 ohm balun is sold for this purpose, enclosed in a weather-tight case, ready to connect between the coaxial cable and the antenna wire.

Table 1. Characteristics of commonly used transmission lines.

Line	Z_0 ohms	Velocity factor	Outside diameter	Maximum working voltage (rms)
RG-8X	52.0	75	0.242	-
RG-8/U	52.0	66	0.405	4000
RG-8/U foam	50.0	80	0.405	1500
RG-8A/U	52.0	66	0.405	5000
RG-9A/U	51.0	66	0.420	4000
RG-9B/U	50.0	66	0.420	5000
RG-11/U	75.0	66	0.405	4000
RG-11/U foam	75.0	80	0.405	1600
RG-17A/U	52.0	66	0.870	11,000
RG 58/U foam	53.5	79	0.195	600
RG-58A/U	53.5	66	0.195	1900
RG-59/U foam	75.0	79	0.242	800
RG-59A/U	73.0	66	0.242	2300
Aluminum Jacket, foam (hardline)				
1/2 inch	50.0	81	0.5	2500
7/8 inch	50.0	81	0.875	4500
1/2 inch	75.0	81	0.5	2500
7/8 inch	75.0	81	0.875	4000
open wire				
TV 1.2 inch	300	95		
1 inch	450	95	-	
300-ohm twin lead	300	80	-	-

You can perform impedance matching with open-wire lines by using a matching network, like the Transmatch or similar circuit that accepts the line impedance at one input and the transmitter impedance at the other. At the antenna, matching methods include a quarter-wave transformer (that is the mean impedance between the antenna and the line), matching stubs, hairpin loops, or a specially designed balun.

coaxial lines

The principles that apply to open- or parallel-wire transmission lines also apply, with some modifications, to coaxial lines. **Figure 3** shows how the impedance of an air-dielectric coaxial line is determined. Keep the conductors from touching each other (and maintain constant spacing), and remember that the insulating material used for support affects the impedance. One thing that is critical with coaxial cable is the power level it can handle. The center conductor is surrounded by insulation, and any heat generated by current flow in the copper is trapped inside the cable. If the heat is great enough the insulation can melt or break down and create a short-circuit. This is usually not a problem at legal Novice power levels, but at higher levels and high SWR, RG-58 and RG-8 cables have been known to burst into flame. **Table 1** shows some important characteristics of a few common transmission lines, including the rms voltage they can withstand.

Be wary of "bargain" transmission lines found at flea markets and surplus houses. These coaxial cables can differ in several ways from what you might buy from a dealer. Only two are serious enough to create problems: the amount of shielding provided by the outer conductor, and possible contamination of the dielectric.

Most coaxial cables used today are flexible; that is, they are constructed with a woven braid as the outer conductor which allows the cable to bend in a reasonable curve without damage. While it is impossible to obtain 100 percent coverage with a braid, some cables come very close (better than 90 percent). It takes only a moment to remove a small piece of outer jacket from coax and look at the amount of visible braid. If the weave is loose, and you can see a lot of dielectric peeking through, the cable is no bargain at any price. Poor coverage lets rf "leak" out and noise leak in. The impedance is not likely to be constant, and losses will be greater than with good cable. Cables with double braid covering can sometimes be found, and these are excellent, although you may have trouble getting both braids to fit into a connector.

Another "gotcha" is contamination of the dielectric. Moisture and gases can be absorbed by almost any plastic, and the dielectric material itself can change chemically because of sunlight and heat. This changes the characteristic impedance of the line, increases loss, and may lead to heating and breakdown of the line at higher power levels. Some cables resist contamination, and are worth looking for if you live in a particularly hot, damp, or smoggy area. Some can even be left lying on the ground or buried without danger of contamination, but should be tested for losses every year or so. Decibel Products VB-8 and Times Wire and Cable Company Impervion are two.

other impedance

The cable television industry uses 75 ohms as its standard for cable and amplifier termination. Surplus cable, often hundreds of feet in length, appears at flea markets and surplus houses at tempting prices. Can you use it? Absolutely. Your transmitter (and receiver) will probably not know the difference. Antennas have to be coupled to the transmission line anyway, so just match it to 75 ohms instead of 50.

The rub is that since most power/SWR meters are made for 50-ohm cable, their indications will not be strictly accurate. They're useful, but you can't be sure that what you see is what's really happening. If the price is right, use the cable and take the indicated SWR and power readings with some skepticism. I'll discuss ways of dealing with this in a future column.

repeater follow-up

I received a letter from Tom O'Hara, W6ORG, with information about 1200-MHz repeaters and equipment. He notes that there are six ATV (Amateur TV) repeaters in Southern California, with 70-cm inputs and 23-cm outputs. The ATV simplex frequency is 1289.25 MHz. PC Electronics,* operated by Tom and Maryann, expects to have a 23-cm ATV transmitter board ready for the Dayton Hamvention this spring. Tom enclosed a list of 23-cm fm repeaters for that part of the country; it shows over 35 repeaters, starting at 1270.1 (input) with the output 12 MHz higher at 1282.1.

According to a technical note Tom included, the Icom RP1210 23-cm repeater can be ordered from dealers on the common 12-MHz input/output pairs, or converted to that spacing by a crystal change. He also suggests using Belden 9913 coaxial cable for 23-cm feedline. Thanks for the suggestions Tom!

questions and answers?

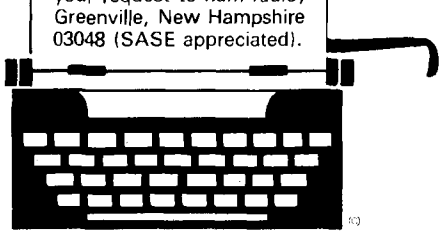
I've had some queries about devoting a portion of each notebook to questions and answers. Are there some particularly nagging mysteries that this column could clear up? What do you think, Novices and Elmers? I'll be glad to hear from you.

ham radio

*2252 Paxson Lane, Arcadia, California 91006-8537.

Invitation to Authors

ham radio welcomes manuscripts from readers. If you have an idea for an article you'd like to have considered for publication, send for a free copy of the *ham radio* Author's Guide. Address your request to *ham radio*, Greenville, New Hampshire 03048 (SASE appreciated).



APRIL 1988 / $2.50

See you in Dayton!

DAYTON Hamvention®

ham radio magazine

multi-featured
inction generator

diagnostic
serial data
latch

frequency
synthesis
up to 2 GHz



hr

focus
on
communications
technology

ham radio magazine

APRIL 1988

volume 21, number 4

T. H. Tenney, Jr., W1NLB
publisher
and editor in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Peggy Tenney, KA1QDG
copy editor

Susan Shorrock
editorial production

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Rally Dennis, KA1JWF
director of advertising sales

Henry S. Gallup
advertising sales manager

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Theresa Ledger
bookstore manager

Phil Alix, KA1IDP
traffic manager

Farm Color
cover

Bill McNabb
hamvention general chairman

Bill Schmid
hamvention exhibits chairman

cover photo

ham radio magazine is published monthly by Communications Technology, Inc., Greenville, New Hampshire 03048-0498
Telephone: 603-878-1441

subscription rates

United States: one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail): one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 31

Microfilm copies are available from University Microfilms, International, Ann Arbor, Michigan 48106
Order publication number 1076

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright: 1988 by Communications Technology, Inc.
Title registered at U.S. Patent Office

Second class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *ham radio*
Greenville, New Hampshire 03048-0498

contents

9 multi-featured function generator
Rod Robbins, WA7IRY

23 more optional notes on the TS-930S
Marv Gonsior, W6FR

28 ham radio techniques: DX is getting better and better! Here's why!
Bill Orr, W6SAI

33 frequency synthesis up to 2 GHz
Douglas R. Schmieskors, Jr., WA6DYW

41 amateur packet radio networking and protocols: part 3
Jonathan L. Mayo, KR3T

47 practically speaking: using the digital frequency counter: some pitfalls
Joe Carr, K4IPV

56 a diagnostic serial data latch
Brian J. Mork, KA9SNF

67 VHF/UHF world: microwave components and terminology: part 2
Joe Reisert, W1JR

83 Elmer's notebook: antenna tuner
Tom McMullen, W1SL

98 advertisers index
6 comments
80 DX forecaster
96 flea market
90 ham mart
92 new products
4 publisher's log
98 reader service
4 reflections



If you take a careful look at our masthead this month you will see that we are in the middle of several changes that deserve a bit of explanation.

You will find that Rich Rosen, K2RR, has left to pursue other activities in the industry. This will give him an opportunity to capitalize on many of the wonderful skills that he has shared with us over the past five years. He has done a superb job at Ham Radio, and he will be missed. However, his new activities offer important opportunities, so we thank him very much for his contributions here and wish him the best of luck as he goes ahead with the next step in his career. He may also have a bit of extra time to get on the air so all of you 75-meter DX'ers had better watch out.

Much of the responsibility of upholding the high standards of the magazine will now fall on the shoulders of Marty Durham, NB1H, who has joined us as technical editor. He brings a variety of rf experience at two defense electronic companies along with a love of contesting and Amateur tinkering and experimentation.

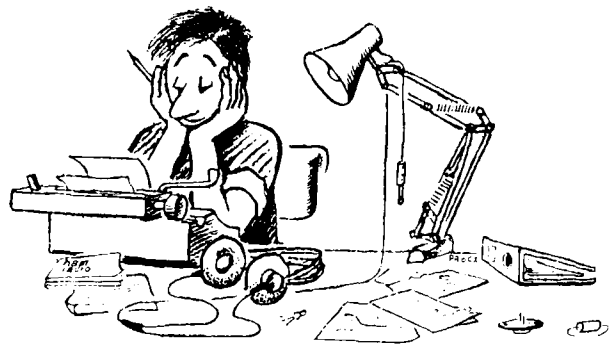
A second well-qualified person who has agreed to help us out is Bob Wilson, WA1TKH, who will be a consulting editor. After he retired from a successful career with a large Boston-area electronics company. Bob and his wife Kit, WA1WQM, co-owned and operated Radiokit for a number of years. As you may know, this firm supplies parts and kits to Amateurs. This experience makes Bob uniquely qualified to advise us as we try to please all of you who like the smell of hot solder.

Finally, to round out another important part of our organization, Henry Gallup has joined us as advertising sales manager. He will be working with Rally Dennis to see that your magazine stays thick and healthy. More ads mean more pages of good articles; so lets all wish him good luck!

Another major change on our masthead is the promotion of Terry Northup to Managing Editor of Ham Radio Magazine. In the few short months Terry has been with us she has proven herself as a most worthy candidate for her new job. She has done a superb job of picking up the many scattered pieces that must go together each month to put out a publication like ours and has done all of this in a most professional way. She has a number of great ideas for the months ahead, and I feel sure that you will find Ham Radio more readable than ever as the magazine responds to her touch.

To round things out, I will reassume the Editor-in Chief's chair, an assignment that should be an easy one considering all the excellent help I'll be getting from Terry, Marty, and Bob along with our topnotch staff including Sue Shorrock, Beth McCormack, and Peggy Tenney.

Skip Tenney, W1NLB



REFLECTIONS

500 manuscripts later

Cedar Rapids presents many different images for a number of people not least of which is the Collins (Radio) division of Rockwell. To me it represents a beginning. In July, 1982, at the National convention held in Iowa, I joined the staff of Ham Radio magazine as technical editor. Having worked in the publishing industry before (rf design, Microwaves), being an active radio amateur, and an electronics engineer I looked forward to the opportunity of combining my technical skills with that of an avocation that I so dearly enjoyed. I was not to be disappointed.

I really consider myself fortunate. An editor sits in a unique position. I have been privy to so many of your ideas, aspirations, plans. I've seen some great manuscripts, and some that required a little more work. During the past five and a half years we've published some material that, because of the combined practical and theoretical talents of the authors, is unique and just doesn't exist elsewhere — not in the professional journals, nor any of the consumer magazines.

We've received your letters, most of which I've tried to answer — from short notes on the back of a QSL card to major treatises. Ah, then the phone calls. How many hundreds of hours have we spent on the landline together, starting with a germ of an idea only to see it flourish into a full blown concept, and eventually a manuscript, though not necessarily on the same subject. I believe, and probably always will, that some of the most fertile, creative minds belong to our group, the radio Amateurs.

For these opportunities I thank you.

Ham Radio now has a new technical editor and Terry Northup, as Skip just mentioned, has been made managing editor. Continue supporting Ham Radio magazine. Keep sending in those quality manuscripts, keep calling in your suggestions. You have an excellent opportunity as always to help shape the future of this magazine as well as Ham Radio in general.

Rich Rosen, K2RR

Are you radioACTIVE?



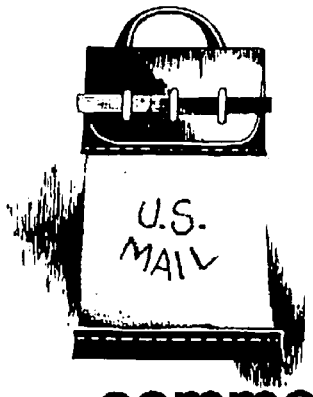
Dean LeMon, KR0V sure is! Dean got active in Amateur Radio when he was 16 years old and earned his Extra Class license in less than four years! "It's a facinating hobby and a great way to meet all kinds of new people from all over the world."

Dean has cerebral palsy and got started in Amateur Radio with help from the Courage HANDI-HAM System. The HANDI-HAM System is an international organization of able-bodied and disabled hams who help people with physical disabilities expand their world through Amateur Radio. The System matches students with one to one helpers, provides instruction material and support, and loans radio equipment.

Isn't it time you got radioACTIVE with the Courage HANDI-HAM System?

Call or write the Courage HANDI-HAM System W0ZSW at Courage Center, 3915 Golden Valley Road, Golden Valley, Minnesota 55422, phone (612) 588-0811.

Are you radioACTIVE?



comments

stamps help some hams

Dear HR:

We are collecting postage stamps to help finance equipment for disabled Radio Hams throughout the world. Stamps from any country and in any quantity would be very much appreciated. These could include new or old stamps removed from or still on their envelopes.

The project has been running for over a year and has been a tremendous success, with local school children helping with the sorting. All stamps should be sent to my address.

John Allsopp, G4YDM
30 Manor Park, Concord Village,
District 11, Washington, Tyne
Wear. NE372BT, England

international telegraph speed contest

Dear HR:

The Blackhawk Chapter of the Morse Telegraph Club has been considering an International Telegraph Speed contest. We would like to run this in conjunction with our Annual Galesburg Railroad Days celebration, generally held on the second weekend of June.

We would like to pattern the contest after criteria used in the 1915 era, awarding medals (probably of pewter or bronze) copied from the original Carnegie Medallion. The contest could apply to both sending and receiving. No bugs would be allowed. There could be separate contests for International and American Morse codes. We would need to charge an entry fee to cover some of the costs — probably $15 to $25.

How much interest is there in such a contest? Because of limited manpower and financial resources, the contest will probably require a special committee under the arm of the international board of the Morse Telegraph Club and/or associated organizations. The Galesburg site provides a fairly central location for both United States and Canadian members and is accessible by rail, bus, and air. We can't think of anything that would be more visible to the public and gain more notice from the media than such an event. Please send your correspondence to me.

Jim Woods, RR4, Box 22
Galesburg, Illinois 61401.

renewed friendship

Dear HR:

Yesterday I went to the dentist office and was reminded of two old friends. When I went to pick up a magazine I observed *ham radio* among those to choose from. Not only that, but I saw the address label of someone I haven't seen in too many years!

I subscribed to *ham radio* for several years until the cost of *all* the radio magazines got beyond me and I cancelled my subscriptions. I was glad to see this copy and had plenty of time to read it. Thanks to Garson Katona for leaving his *ham radio* in the dentist office. Needless to say, I thought he had a good idea so I left the magazine for the next person.

Thanks and 73. Still good reading.

Paul Woolverton, W2AEI
Trenton, New Jersey 08611

multi-featured function generator

Test bench instrument features versatility and low cost

Any Amateur who enjoys experimenting knows the frustration of not having the test equipment needed to troubleshoot a problem. I had gradually accumulated most of it, but was still missing an audio function generator. I hadn't planned to build one, but a brief scan of equipment catalogs quickly changed my mind: the equipment had a higher degree of sophistication than I needed and was also expensive.

Function generator projects have been around for years and it's sometimes difficult to find one whose technology falls somewhere between bare basics and high complexity. My requirements for a function generator included: dc offset capability, external frequency measurement, at least one very low frequency range, separate simultaneous outputs, low output impedance, and continuously variable waveshaping. This project is an attempt to fill a niche sometimes neglected in Amateur circles — a simple, versatile, and easily reproduced function generator for someone who needs more than just a simple signal source, but not lab-standard features or performance.

It isn't necessary or even desirable to duplicate this instrument exactly, since each builder may have different operational needs. The circuit is simple enough for anyone with a little experience in junkbox improvisation to reproduce a working model. The total cost, even with all parts purchased new, is about $35.

features

I chose the XR-2206 monolithic function generator IC as a basic building block; I'd used it before and knew its performance was predictable. I claim no originality for any of the individual circuits presented here — only for the way they're used in my own application. The basic circuit is adapted from the 1985 Radio Shack Semiconductor Reference Guide[1], which is similar to EXAR's data sheets (**fig.1**).

The prototype evolved into its final version over several months. The final design features include:

- Three separate, simultaneous outputs for sine/triangle, square wave, and constant amplitude pulse (for driving a frequency counter, or oscilloscope triggering).
- Usable frequency range from 1 Hz to 100 kHz.
- DC offset, with a momentary spot button to temporarily disable the ac portion of the output signal, so the dc component can be viewed alone on an oscilloscope display or volt-ohm-millimmeter for easy dc offset adjustment.
- Variable amplitude from ≈ 100 millivolts peak-to-peak to ≈ 15 volts peak-to-peak, with switchable attenuation. (The attenuation ratio is about 10:1.)
- Coarse and fine frequency adjustment controls.
- Stable, relatively clean waveforms (although probably not lab standard).
- Continuously variable waveshaping between sine and triangle waves.
- Fairly low output impedance, with almost 5 watts average output power (into 8 ohms).
- *Virturally indestructible output circuitry.*
- Low cost, easily obtainable components.
- Simple, easy to reproduce circuit.

dc offset

My first addition to the original circuit was dc offset capability. The logical starting point was at the R_A-R_B voltage divider network between U_1 pins 3 and 4 (point 1 in **fig. 1**). The voltage at point 1 creates a dc component at the noninverting input, causing a dc component to appear in the output signal at point 2, roughly equal to half the total supply voltage.

In the original XR-2206 circuit, this component in the output provides the required bias for the base of an external amplifier transistor and eliminates the need for a base biasing network. Replacing the R_A-R_B divider network with a potentiometer of the same total resistance made the dc offset of Q_A's output theoretically equal to the dc voltage present at the wiper of the pot (minus the base-to-emitter voltage drop). Variable dc offset occurred as the pot was adjusted.

This worked until I tried some routine gain adjustments. A resulting problem was that the resistance of the gain control pot, R_C, comprised a small but definite portion of one leg in the voltage divider system

By Rod Robbins, WA7IRY, 22435 Bents Road, Aurora, Oregon 97002

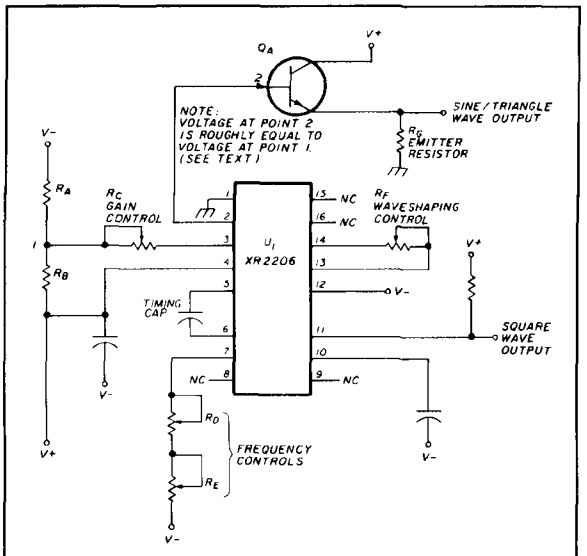


fig. 1. The original XR-2206 function generator circuit, adapted from the 1985 Radio Shack Semiconductor Reference Guide.

and whenever the gain was varied, the divider ratio changed slightly, in turn changing the dc offset. This unexpected "feature" meant that the dc offset had to be zeroed each time the gain was changed.

The solution was simple. DC offset can also be achieved in an external base-biasing circuit of output amplifier Q_3 (see **fig. 2**). I modified the circuit with a dc blocking capacitor in the IC's output to cut off the small, but annoying, interaction between gain and offset adjustments. I used a surplus 30-k, 10-turn pot as a voltage divider in Q_3's base circuit resulting in a variable base bias voltage as the pot was adjusted (R6 in **fig. 2**). The emitter voltage automatically follows the base voltage, minus the base-to-emitter drop.

While the 10-turn pot provides smooth, high-resolution adjustment, even at high oscilloscope magnification, a standard pot will work. Use one with the smoothest movement and widest adjustment sweep range you can find. Note the circuit now has two dc offset adjustments: a set-and-forget trimpot for initially setting the offset in the original IC circuit, and an oper-

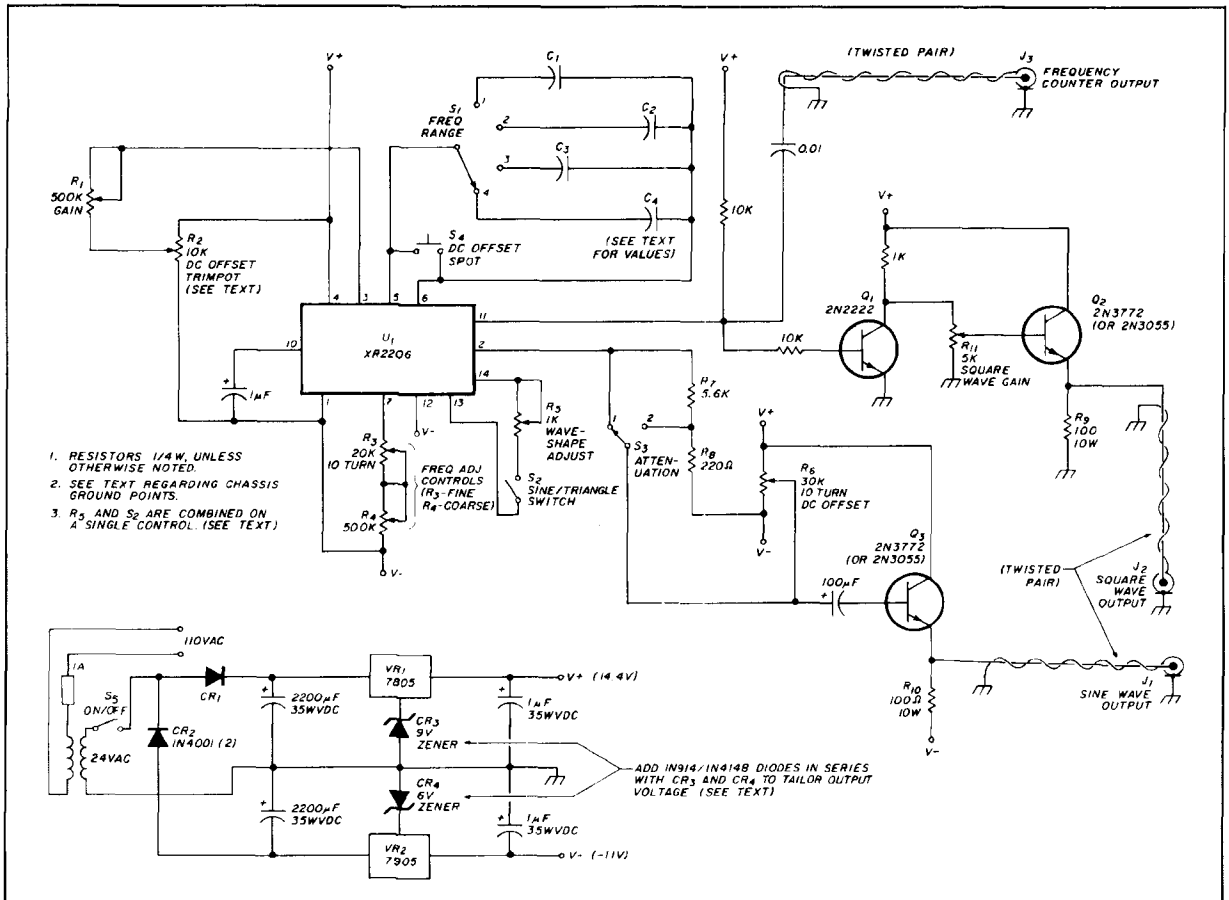


fig. 2. The final design. Values for the frequency range capacitors, C_1-C_4, are given in the text. Also, note the diodes inserted in the voltage regulator ground return leads to tailor the output voltages.

ational control in the output amplifier circuit. (More on this later.)

frequency adjustment

It's easier and more accurate to read frequency on a counter or oscilloscope. Achieving accuracy and/or linearity on an analog dial face is tough, even for commercial devices.

I added another simultaneous output, J_3, producing pulse output for driving a frequency counter or oscilloscope. Even if a counter isn't available, the pulse output frequency can be approximated on an oscilloscope more accurately than on any homebrewed dial face. You can get smooth, high-resolution frequency adjustment by using a pair of good quality pots; one 500 k for coarse adjustment, and one 30-k unit (multiturn if available) for fine adjustments. I used another surplus 10-turn pot of the same type as the dc offset pot. Dial face markings and time-consuming calibration weren't necessary.

frequency ranges

Frequency ranges are provided by four mechanically switched capacitors. Most homebrew function generator designs I've seen use four or five frequency range capacitors, with values in exact decade steps, to provide (theoretically) a decade step function between ranges. This seldom works in practice, because of variables like component tolerance and stray capacitances in the wiring, switches, and connections.

My design uses external frequency measurement, so I decided that convenience rather than a strict mathematical relationship would determine the bandwidths and range overlaps. Capacitor values determined by experiments allowed me to set up my unit to provide wide, overlapping coverage of portions of the audio spectrum that I needed most. The values are shown in **table 1**.

The range overlaps have no obvious mathematical relationship, nor is the bandspread linear, but this doesn't matter as the frequency is read on external instruments rather than a dial face.

I needed only four ranges, so two positions on the six-position rotary switch are unused. The builder can use as many or as few positions as he wants, as well as different value capacitors to make the ranges.

switchable attenuation

At this point, the lowest amplitude available from the unmodified circuit was about 800 millivolts peak-to-peak. Because I wanted the option of using the device at lower signal levels, I installed a voltage divider, R_7 and R_8 (**fig. 2**), in the IC output circuit, just ahead of the blocking capacitor. I experimented to find values that provided about a 10:1 attenuation ratio. They don't mathematically "compute" to this ratio because the input impedance of the emitter follower is involved in the calculation, so it's not really a simple voltage divider relationship. Start out with my attenuation values and change them if you want a different ratio.

Table 1. Frequency-range capacitors C1-C4

Frequency range (hertz)	Capacitance (microfarads)
1-400	C_1 0.2*
30-5000	C_2 0.1
200-10K	C_3 0.01
8K--100K	C_4 0.00022

*C_1 actually consists of two 0.1-μF capacitors in parallel.

When S_3 is set at position 2, most of the output voltage is dropped across R_7, allowing only the portion of the output signal's amplitude across R_8 to be presented to Q_3 input. When the switch is in position 1, the entire signal amplitude is dropped across both R_7 and R_8 and presented to Q_3. This provides clean, well-defined signals down to about 100 millivolts peak-to-peak, not bad for a homebrew device.

waveshaping adjustment

The waveshaping control is a ganged switch potentiometer combination (R_5-S_2) allowing the waveshape to be varied from a distorted sine wave to a sharp triangle wave as the resistance of R_5 increases. At the end of the pot rotation, S_2 opens, placing an infinitely high resistance across IC pins 13 and 14, giving the triangle waveform maximum sharpness.

output amplifiers

This unit uses separate emitter-follower amplifiers for both square and sine/triangle wave outputs, providing adequate power for driving low-impedance loads. Note that according to the Jameco catalog[2] the 2N3772 transistors are rated for a collector current of 30 amps. This seemed like a case of overkill, since the power supply is current limited to 1.5 amps per side. But, while thumbing through parts catalogs for suitable output transistors, I couldn't get past the fact that these monsters are only 89 cents each in single-lot quantities, so I chose the 2N3772. You can use the 2N3055 or similar NPN devices. This type of power transistor is not really necessary but makes the output amplifiers virtually indestructible, at least from the current available from the function generator.

power supply

I used a split-polarity power supply to enable dc coupling capability. An exact duplication of my power supply isn't necessary — many generic designs have been published. I happened to have an outboard non-

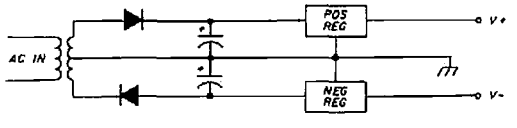


fig. 3. Block diagram of a generic split-polarity power supply, using a centertapped transformer.

centertapped transformer, so I used the circuit shown in **fig. 2**. A centertapped junkbox transformer with adequate output voltage would also work. (See the example in **fig. 3**.)

There are a few important considerations whatever power supply design you use. The positive and negative voltages must have enough difference between them to provide adequate voltage swing in the output signal. In my unit, the maximum output amplitude was about 65 percent of the available supply voltage. Don't exceed the XR-2206's maximum rating of 26 volts.

In my design I used 7805- and 7905-series 5-volt positive and negative fixed regulators. I tailored the exact voltage for each side by inserting 1N4148 diodes in the ground return lines, in series with the zener diodes. By hand selecting diodes in the protoboard version of the circuit, I achieved the voltages shown (a total of 25.4 volts between the positive and negative sides). This was measured on a good-quality digital VOM, and was as close as I dared to approach the 26-volt maximum.

Note that I used fixed regulators only because I had them. Adjustable regulators, like the LM317 and LM337 series, can also be used for simple and precise voltage settings.

Another consideration is that the positive voltage should be a few volts higher than the negative. Initially, I made the positive voltage about 0.7 volt higher, to compensate for the base-to-emitter drop in the output amplifier. This made the sine/triangle wave output signal nearly symmetrical as the amplitude reached the clipping level. Because the maximum square-wave output was only +6.5 volts, I readjusted the positive voltage to about 3.4 volts higher than the negative. To gain a higher square-wave output, I had to sacrifice a few volts of sine/triangle wave output. This compromise really isn't necessary if you don't need the higher square-wave output.

construction

As you can see in **photos A** and **B**, I used simple, straightforward construction methods and a lot of junkbox parts. Most of the circuit is built on an 3-3/8 by 2-7/8 inch Radio Shack "universal pc board" that

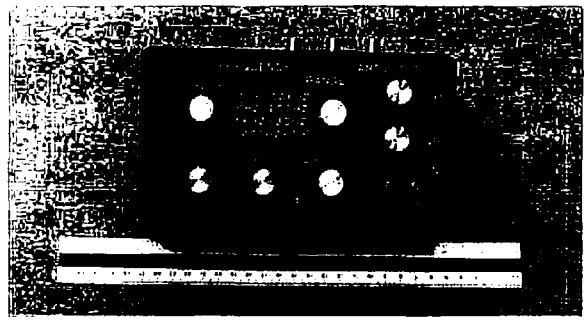


photo A. Top view of the completed function generator shows panel controls.

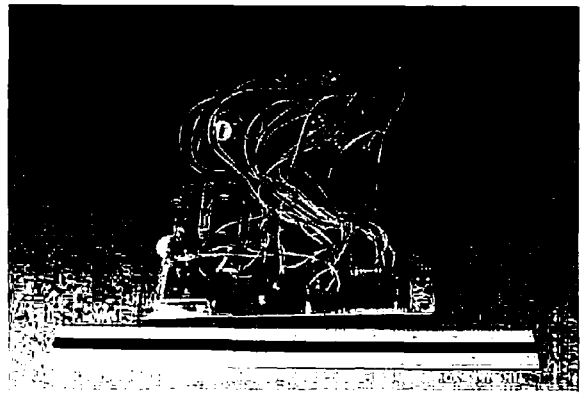


photo B. Inside view, shows power supply components mounted on the left side of the metal lid, which serves as the bottom. Power resistors R_9, R_{10} are located over the electrolytic capacitors.

has solder-ringed holes, two bus lines, and a grounding strip. Parts placement or layout isn't critical. The frequency ranges of the function generator are low enough that stray capacitances and inductances from the board, IC socket, or wiring don't seem to cause any problems.

I built the unit inside a 7-3/4 by 4-3/8 by 2-3/8 inch Radio Shack experimenter box, using the widest plastic side of the box for the faceplate and controls. The removable metal lid became the bottom, was drilled for mounting the two power transistors, and serves as a heat sink. (See **photo C**.) It was not used as an electrical ground plane as such. All chassis ground points on the schematic return to a single tie point on one of the terminal strips. This technique works well in this kind of circuit for eliminating ground loops, oscillation, and instability.

I extended the four bottom rubber feet slightly by inserting small squares of double-faced tape on the bottoms before mounting them to the metal lid.

The ac power transformer was used outboard because there wasn't room inside the cabinet (see in

photo B). This wasn't a problem in my case because the transformer was designed to be freestanding. I simply removed the cover, took out the unneeded rectifier components, and installed a fuse holder. The transformer's output plugs into the back of the function generator through a mini phone plug and jack.

The layout of the faceplate and output jacks allows enough room between controls for convenient operation without bumping or moving the other settings. I used RCA phono-type output jacks installed on the back of the unit. Photo D shows the finished product complete with outboard transformer and a set of homebrew test leads.

getting the parts

None of the parts for this project are unusual or hard to come by. In the prototype, I tried different pots ranging from 15 k to 50 k for both the dc offset and fine frequency adjustments, with no noticeable difference in results. They don't need to be multiturn types, although they make adjustment smooth and precise.

Whatever you can't find in the junkbox or on flea market tables, you can get at Radio Shack or from the suppliers listed in table 2.

testing and alignment

After the unit is assembled, check the wiring connections against the schematic and inspect for solder bridges and tiny wire strand fragments. When you're sure the wiring is correct, leave the XR-2206 out of its socket, turn on the power, and watch closely. If everything seems right (it's normal for the power resistors, R_9 and R_{10}, to be quite warm but not smoldering), turn the power off and insert the 2206. Preset the following controls:

1. Frequency range switch S_1 to second or third range.
2. Gain (amplitude) control R_1 to midrange.
3. XR-2206 dc-offset trimpot R_2 to midrange.
4. Frequency adjustment pots R_3 and R_4 to midrange.
5. Main dc offset pot R_6 to midrange.
6. Waveshape adjustment pot R_5 to midrange.
7. Square-wave gain pot R_{11} to midrange.
8. Attenuation switch S_3 to OFF (Position 1).

Connect an oscilloscope to the sine/triangle wave output, and turn on the power. Hold the dc offset spot button in, and adjust main dc-offset pot R_6 to verify that the dc level varies to the expected positive and negative levels. Remember, it's normal for the positive limit to be a few volts higher than the negative. If this checks out, center R_6 to 0 volts, and release the spot button.

At this point, a signal of some type should appear on the oscilloscope. The exact shape or frequency isn't important; simply adjust the frequency ranges on the oscilloscope and/or function generator to display two or three complete cycles of whatever waveform you see, and reduce the gain to just below the clipping level.

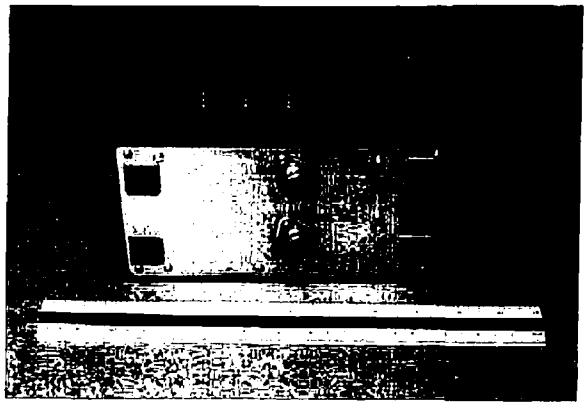


photo C. Mounting arrangement for the power transistors and rubber feet on the metal lid, which serves as the bottom of the function generator. Along the top edge are the three RC phone jacks for the (left to right) sine/triangle, square wave, and frequency counter outputs, respectively. The 1/8th inch phone jack at the far left is the ac input jack from the outboard transformer.

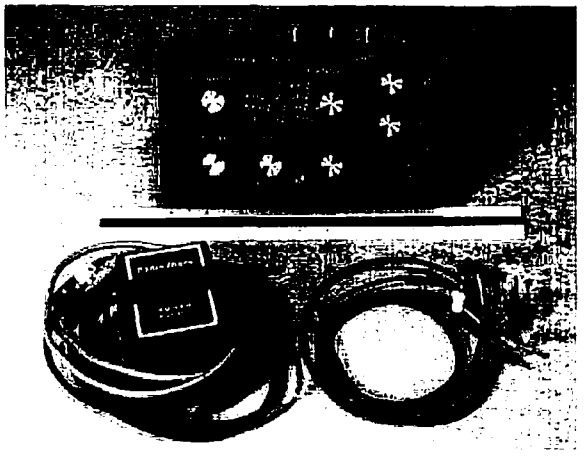


photo D. The completed unit, shown with the outboard power transformer and set of homebrew test leads.

Slowly increase the gain until the waveform clips slightly, on either the positive or negative peak. Adjust IC dc-offset trimpot R_2 until the waveform drops below the clipping level. Repeat these two steps until the waveform is centered between the positive and negative clipping points. The trimpot is set properly when the waveform clips on both positive and negative peaks at the same time, just as gain reaches the clipping point. Note that this is a set-and-forget control; dc-offset adjustments during normal operation will be done with R_6.

Now adjust the waveshape control, the R_5-S_2 combination, through its entire range, and verify that the

Table 2. Suggested parts suppliers

Jameco Electronics, 1355 Shoreway Boulevard, Belmont, California 94002

1. 2N2222A npn general-purpose transistor, 3/$1.00*
2. 2N3772 npn power transistors, $0.89 each (two required).
3. 7805 5-volt positive voltage regulator, TO-220, $0.49.*
4. 7905 5-volt negative voltage regulator, TO-220, $0.59.*
5. LM317T adjustable positive voltage regulator (alternative to no. 3), $0.79.*
6. LM337T adjustable negative voltage regulator (alternative to no. 4), $0.99.
7. XR-2206 monolithic function generator chip, $3.95 each.
8. 2200 μF electrolytic capacitor, 25 working volts dc, $1.25 each (two required).*

Radio Shack

1. Six-position rotary switch, catalog no. 275-1386 (only four positions used), $1.19.
2. Plastic experimenter box, 7 3/4 by 4-3/8 by 2-3/8 inches, catalog no. 270-232, $2.99.
3. Universal PC board, 3-3/8 by 2-7/8 inches, catalog no. 276-168, $1.95.
4. 100-ohm, 10-watt power resistors, catalog no. 271-135 (two required), 2/$0.89.

Miscellaneous parts such as resistors, capacitors, wire, hardware, and knobs may be purchased locally.

*Indicates that these parts may also be purchased at Radio Shack.

waveform varies from a "fat" sine wave to a sharp triangle wave, and all points in between. When the control's rotation reaches the point of opening S_2, the waveform should be a very sharp triangle. If the wave shape changes abruptly from a sine wave to a triangle, then the leads to R_5 are reversed.

Switch the attenuation in and out at various amplitudes with S_3, and verify that the signal is attenuated to about one-tenth its normal strength. (Change the value of R_8 for the attenuation you want.)

Connect the oscilloscope to the square-wave output. Vary the square-wave gain control, R_{11} and make sure the output is adjustable from 0 volts to between 60 and 70 percent of $V+$. The waveform should have sharp rise times and should not go negative. My unit produced clear, crisp waveforms until the frequency reached well over 50 kHz, the positive-going edges began to curve, and the duty cycle widened. (Some of this may have been capacitance in the oscilloscope probes and cables.)

Finally, connect the oscilloscope to the frequency counter output. You should see a pulse waveform, with a fairly constant amplitude regardless of any other control settings. If a counter is available, connect it temporarily to the sine/triangle or square-wave output and increase the gain until the counter displays a steady count. Then check the displayed frequency against an approximation from the pulse output measured on the oscilloscope.

This completes the alignment and testing procedure. Connect the frequency counter to counter output J_3.

performance

The completed function generator works well for a relatively simple homebrew device. Its output is more than adequate for almost any type of testing or experimentation a ham is likely to do. The specifications for my model are shown in **table 3**. When operating into an 8-ohm load, the undistorted output is about 2.2 volts peak-to-peak, with the dc offset set at 0. By moving the offset to about +4.5 volts, I was able to get almost 6 volts peak-to-peak of undistorted sine wave — plenty of power to make an earsplitting test of any speaker.

The frequency stability was one of the best results. I let the generator run overnight, connected to the frequency counter. The next morning, the frequency had changed exactly 3 Hz — and some of that could have been drift in the counter! The waveforms are very stable, relatively clean, and can be adjusted to almost perfect sine or triangle waves with the waveshaping control. **Photos E, F,** and **G** show the actual triangle, sine and square waveforms, respectively. Only when the frequency approaches 75 kHz do the waveforms begin to show distortion that can't be compensated by waveshaping (a possible defect in the oscilloscope probes).

Table 3. Performance data maximum output voltage swings (before clipping).

	waveforms (all voltages peak-to-peak, frequency = 1 kHz)		
loads (ohms)	sine (volts)	triangle (volts)	square (volts)
50k	15.0	11.0	10.2
500	13.8	10.8	10.1
50	8.4	8.4	8.9
8	2.1	2.0	5.2

suggestions for use

The function generator provides a clean, stable audio signal source for most Amateur-level testing operations. **Figure 4** shows a few suggestions for sample circuit connections.

In example A, assuming the device being tested needs a high-impedance source, simply insert a resistor in series with the function generator's output. Because the generator's output impedance is low compared to most high-impedance circuits, the resistor value can be the same as the tested circuit's impedance. This value will probably be high enough to

Join AMSAT...Today

'Amateur Radio Satellite OSCAR 10 provides:

- **A New Worldwide DX Ham Band** open 10 hours a day.
- **Rag Chew With Rare DX Stations** in an uncrowded, gentlemanly fashion.
- **Popular Modes In Use:** SSB, CW, RTTY, SSTV, Packet
- **Full Operating Privileges** open to Technician Class licensee or higher.

Other AMSAT Membership Benefits:

Newsletter Subscription:
Dependable technical articles, satellite news, orbital elements, product reviews, DX news, and more.

Satellite Tracking Software
Available for most popular PCs.

QSL Bureau, AMSAT Nets, Area Coordinator Support, Forum Talks

Construction of Future Satellites For Your Enjoyment!

AMSAT Membership is $24 a year, $26 outside North America. VISA and MC accepted.

AMSAT
P.O. Box 27
Washington, DC 20044

301 589-6062

↙ 110

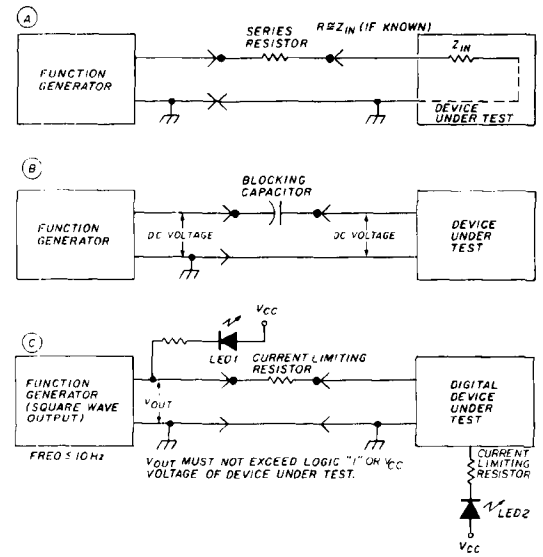
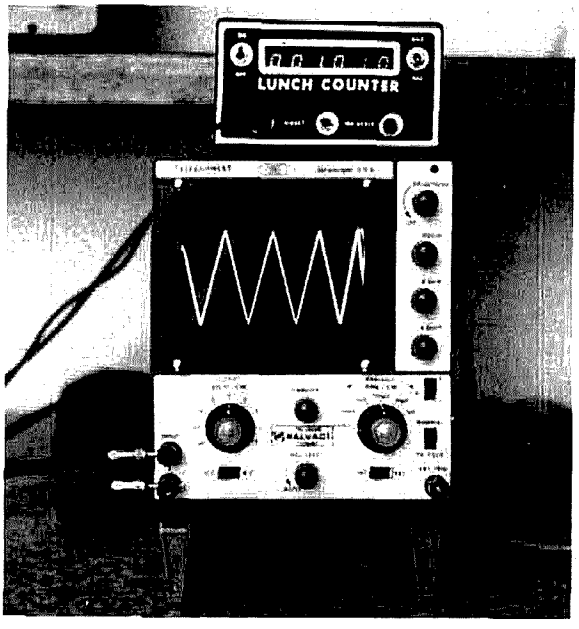


fig. 4. Suggested circuit connections. (See text for details.) Example A shows using a series resistor to simulate a high-impedance signal source. Example B demonstrates the use of a dc blocking capacitor, to either protect the device under test from inadvertent dc output from the function generator, or to protect the function generator from high dc voltages present in the device under test, such as those found in tube-type equipment. Example C shows the use of current-limiting resistors, to prevent excessive current sinking or sourcing when the square-wave output is used for driving digital devices, as in a clock. Note that an LED can be used to visually monitor the clock speed if it's lower than 10-15 Hz. This also requires a limiting resistor, as shown.

hide, or swamp out, the function generator's impedance. The series resistor enables the function generator to simulate a high-impedance signal source.

When the dc offset is zeroed, the function generator outputs only ac. However, it's always possible to bump the dc-offset knob, inserting a dc component into the signal. If the circuit you're testing could be damaged by dc, use the blocking capacitor shown in example B. Conversely, if the device to be tested has dc voltages high enough to damage the function generator, use the blocking capacitor to protect it. Be sure the voltage rating of the capacitor is high enough.

Example C shows the square-wave output used with digital devices. The main reason I designed one of the frequency ranges to be as low as 1 Hz was so I could use the generator as a low speed clock for digital prototyping. It's fun to connect a shift register or digital counting circuit of some type, using LEDs to visually monitor the outputs. With a slow speed clock, you can actually watch the device operate. Just make sure the output voltage doesn't exceed the maximum vol-



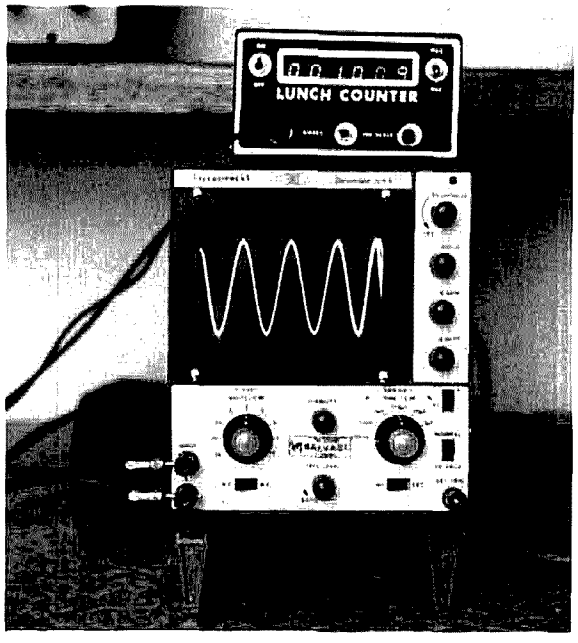




photo E, F, and G. Oscilloscope displays of the triangle, sine, and square-wave outputs, respectively. The photos were taken at a frequency of about 1 kHz, with amplitudes of about 12 volts peak-to-peak, into a 10-k load. The variable timebase was adjusted to display several cycles for the photos, so the horizontal scale divisions don't correspond to the indicated frequency.

tages required by the chips under test. For example, more than about 5.1 volts will often damage TTLs.

To make the square-wave output positive only, Q_2's emitter resistor is connected to ground, rather than the negative side of the power supply. This means the amplifier output resistance, as seen by the circuit being tested, is only about 100 ohms and problems such as excessive current sinking or sourcing from the external circuit could arise. If this happens, use a series current-limiting resistor in the output.

conclusion

For a minimum amount of time, money, and junk-box parts, you can construct an inexpensive, versatile test instrument with some of the features found in commercial-grade units. This building-block project uses established, proven circuitry, no exotic parts or techniques, and can be easily assembled by anyone with a little experience. The circuit's performance is tolerant of changes in the prototyping stages, so the builder can improvise, modify, and use materials already on hand.

Anyone who undertakes a project like this can't help learning more about electronics, regardless of his intentions. I now find myself spending more time experimenting because I no longer waste time throwing together a quick and dirty signal source for testing circuits. It was well worth the effort.

I'll try to help with any problems, and am always interested in hearing about new experimenting techniques, gadgets, and gizmos. Just be sure to include a SASE with any correspondence if you'd like a reply.

references

1. *1985 Semiconductor Reference Guide*, Radio Shack (Division of Tandy Corporation), 1985.
2. *Jameco Electronics 1987*, Jameco Electronics, Inc., 1987.

ham radio

Improving an already fine transceiver

more operational notes on the TS-930S

I was gratified to hear from users of the Kenwood TS-930S who read my earlier article[1] that many operators are interested in improving their SSB transmitted spectral purity, that is, the reduction of Intermodulation Distortion (IMD)*. As a result, I began investigating the radio's characteristics under varying conditions and came up with several modifications.

SSB linearity

The TS-930S obeys the same principles for linearity (reduced output power and biasing for the most linear region of the devices involved) as other high fidelity, linear systems. Kenwood's Factory Service Bulletin number 867 dated March 29, 1983 notes that the quiescent collector current I_{CQ} of both the drivers and output transistors, MRF-485s and MRF-422s, was increased from 75 mA and 0.5A to 85 mA and 1.0A, respectively. This change made an immediate, audible improvement in the SSB speech quality because the devices were moved closer to their Class A and Class AB1 regions. Biasing the MRF-422s still closer to their Class AB1 region affords even more improvement, most noticeable in the higher order products because bi-polar devices generate more of these products than thermionic devices. Therefore it is necessary to raise the I_{CQ} of the MRF-422s in the power amplifier to a value greater than 1.0A and measure the results with a two-tone generator and spectrum analyzer. By adjusting the bias level potentiometer, VR1, located in the rf shield compartment. The increased device dissipation is easily handled in both the TS-930S and TS-940S because these transistors are operating well below their thermal power dissipation limits. The adjustment is read on the radio's multimeter, and data resulting from changes in the operating parameters is provided in **table 1**. Note that the I_{CQ} of the MRF-485 drivers was not changed; they are already operating well into their most linear region (Class A). Motorola's maximum and typical 3rd order IMs are −36 and −41 dB for the MRF485 and −36 and −39 dB for the MRF422, respectively. Data was taken at 150 watts PEP *per device* at 30 MHz with an I_{CQ} of only 150 mA! Frequency, device matching, and impedance matching affect the results. The TS-930S measurements are intended as guidelines for the reader to improve his transmitter's linearity.

For some contest operators, it is remotely possible that under extreme temperature and humidity conditions a small, quiet, external Whisper™ fan could be used to simultaneously cool the rf and power supply heat sinks. It is also easy to return the power amplifier quiescent collector current to 1.0A for those periods. The test measurement setup is shown in **fig. 1**. All the elements are self-explanatory with the exception of the TS-144/U, a two-tone rf generator whose products are specified to be at least 66 dB down and whose function here is to calibrate and verify the performance of the TS-1379/U. It was designed as a complementary piece of test equipment to the analyzer. In my application in class AB1, the drive requirement is a modest 30 watts PEP. Those using the popular 8877 in Class AB2 should be able to closely duplicate this performance. It should be noted that the TS-930S will easily meet its TX IMD 3rd order performance specifications of less than −31 dB.

A point worth remembering is that quality transistors and tubes, like those supplied by Motorola and Eimac, are specified as exhibiting odd-order IMD products being down so many dB from desired (two) equal tone output signals. This is in accordance with a military standard specification number 1311B-2204B.

*IMD is best defined as "the measured distortion of a linear amplifier as expressed in power in decibels below the amplifier's peak power or below that of one of two tones employed to produce the complex test signal."

By Marv Gonsior, W6FR, 418 Adobe Place, Fullerton, California 92635

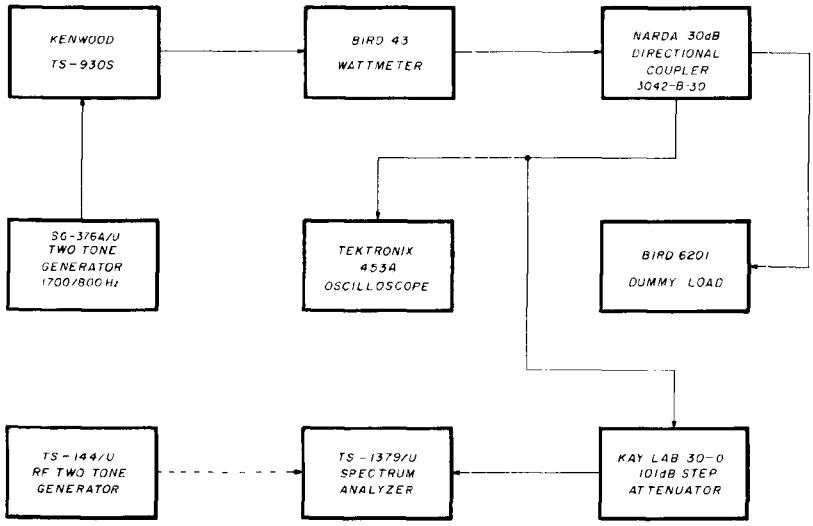


fig. 1. 50-ohm IMD test set up.

Table 1. TS-930S TX IMD data: I_{CQ} versus P_O

Serial Number: 4,010,265

Frequency: 14,175 kHz

Tones: 800 and 1700 Hz

Processor: Off, except as noted.

ALC: Mid-Red Scale (1)

Power Meter: Bird 43

Icq	1.0A		1.75A		2.5A		(4) 1.0A	(5) 2.5A
P.E.P. Watts Output	100	50	100	50	100	50	100	25
Distortion Product (2)								
3	36	39	35	38	34	39	20	46
5	39	42	40	44	40	47	29	48
7	43	47	44	49	45	55	41	58
9	47	53	54	60	54	58	43	59
11	52	56	57	(3)	58	(3)	45	60
13	53	57	59	(3)	60	(3)	48	(3)

Notes:

1. ALC indicated only at the 100-watt level.
2. All distortion product levels are expressed in – dB and referenced to the PEP (see text).
3. Indicates greater than 60 dB.
4. 6 dB average processing and ALC as in (1) above, customary operation by many users.
5. The ultimate linearity employing 0 ALC and compression, with optimum power level.

Amateur radio equipment and many commercial equipment suppliers have chosen a less conservative JEIA/EIA standard which makes the same test, but references the PEP, providing a -6 dB paper improvement in the numbers. Because many Amateurs are accustomed to the latter method, it is used here. Therefore, the tests are the same but the numbers are different. Collins, to my knowledge, specified the IMD in all SSB equipment (both exciters and amplifiers) by the military method of referencing one tone of a pair. A discussion on this subject written by Granberg[2] makes informative reading. Rusgrove's article[3] on the subject of spectrum analysis is also recommended reading for the serious operator.

don't overlook the amplifier linearity response

We tend to think in terms of exciter IMD performance specifications while missing the fact that it is the overall system which governs final signal quality. In other words, the final amplifier must be more linear to preclude degradation of the driving signal. Good engineering practice dictates that the final amplifier should be 10 dB better than the exciter alone. It is generally accepted that a 3 dB better differential (amplifier with respect to exciter) will result in a 3 dB degradation of the exciter's performance. Therefore, great care must be exercised in the selection and operation of the final amplifier for optimum linearity in a system. Orr published an article on IMD in linear amplifiers with a wealth of information on vacuum tube applications.[4]

On this subject, a few caveats are in order. Don't load a linear under single-tone conditions, as optimum power output and linearity will be found only under a complex waveform such as a voice and a two-tone will be only an approximation. Do operate the filament of thoriated tungsten tubes at slightly under the manufacturer's specified voltage for longest tube life and greatest linearity using step start. Measure the filament voltage at the tube socket under load with an accurate voltmeter. It follows that tubes which are being operated under manufacturer's specified parameters will generally last longer and be cleaner than those that are not. There is a strong case for rf negative feedback, though as always, there is a price (which in this case may be in terms of dollars and additional drive required).

rx single signal reception

Many of us have found that the alignment of the SSB carrier oscillators in the TS-930S and the TS-940S seems slightly high on the slope of the sideband filter. So, when tuning through zero beat of a CW carrier in the sideband mode, the unwanted opposite sideband will be audible. Test for this by enabling the 100-kHz marker signal, tune all the way through it in either the USB or LSB mode, and listen for any carrier on the unwanted side. The remedy (which improves SSB selectivity) is to move the carrier oscillator(s) a little bit further down the slope of the filter while listening until the unwanted sideband disappears. Adjustment(s) for this are TC4 (USB) and TC5 (LSB) located on the Signal Board. (See the service manual for further details and parts locations.) In my radio the two optimum frequencies are 8831.631 and 8828.390 respectively with the slope tuning wide open, as measured on pin 2 of connector 24 using an HP5381A counter. Periodic re-nulling of the balanced modulator is recommended, especially after any carrier oscillator adjustment.

receiver reciprocal mixing

This well-known phenomenon is common to all receivers incorporating PLL frequency synthesis; the subject has been covered comprehensively by Rohde.[5] Kenwood and others have made improvements in this area for the TS-940S with additional filtering in the PLL circuit. A constructive improvement for the TS-930S was provided by W4CG, and as a result of his work the author simplified that filter into a simple low-pass. It consists of one disc capacitor providing the desired high frequency roll-off and resulting in a 6 dB improvement in the self-generated receiver noise, under conditions stemming from very high level received signals. The filter installation circuit is shown in **fig. 2**, and the test procedure in **table 2**. As in all circuit designs, remember that the buildup of component tolerances

Table 2. Reciprocal mixing filter test procedure and installation.

- Enable the 100-kHz marker (14.200 MHz).
- Inject a signal at 14.175 MHz (using any available "clean" generator) and increase its output until the 14.2-MHz marker level at the audio output decreases by 3 dB.
- Turn off the marker generator and notice that reciprocal mixing noise is audible at that frequency and beyond.
- Plug in capacitor C1 and a 6 dB reduction in this noise should occur. (The amount of attenuation is measured at the headphone terminal of the receiver using a Triplett model 630A meter operating in the output, dB scale.) This procedure simulates a strong, close-in signal which is capable of causing the receiver to generate the reciprocal mixing noise. The filter, unfortunately, has no measureable effect on the transmitted signal.

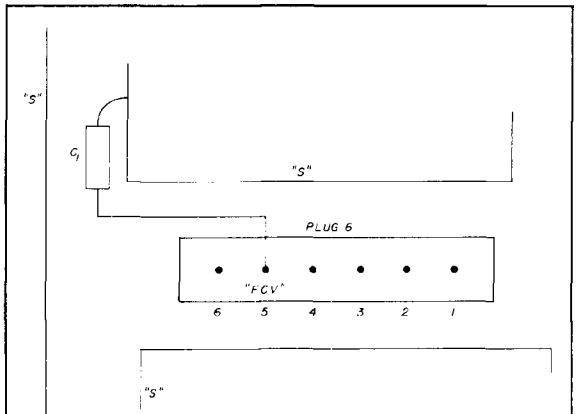


fig. 2. Filter installation reduces receiver non-reciprocal mixing and loop bandwidth.

and alignment will be different in each radio. In my TS-930S the installation was effective using a *measured* 0.022 disc capacitor. Because this type of capacitor generally has wide manufacturing tolerances in addition to those inherently in the radio, the capacitor should be measured accurately before installation.

The following test will indicate if the capacitor is correct. With the mod in place, put the transmitter in the QSK mode with a 100-kHz split and keyed at about 45 w.p.m. If the capacitor is too large, a noticeable delay will be found in the PLL seeking to first acquire the alternate frequency, or a slight chirp will be noticed on the leading edge of the CW signal indicating that the loop time is marginally slow. If this is the case, reduce the value of C1 accordingly. A primary concern, with respect to loop filters like this, is that the loop's acquisition time will always degrade with any filtering, and consequently the exact value is a trade-

off. In one extreme, the loop time will be so slow that it will fail to function. On-the-air testing of this filter has demonstrated that it will be successful only to the extent that the large signal which generates this type of noise is free of noise sidebands; otherwise, it will be in your passband and nothing will cure it. However, the results of this mod under clean signal conditions have been verified in four other radios.

automatic antenna tuner

As users of this versatile option have learned, it is a valuable investment from the standpoint of resale and performance because it provides a very effective match from the transmitter to the outside – quite essential in broadband solid-state equipment. The other benefits in using this unit may not be recognized. Second harmonic suppression is increased by a measured 6 dB in my case when it is operating in the "T" match mode occurring from 3 to 14 MHz. Above that, it operates in the ""Pi" configuration which should yield additional attenuation. It prevents automatic shutdown due to a high VSWR, which not only reduces the power output but increases the distortion products since the power amplifier is no longer operating in its most linear mode. The tuner will *not* provide the desireable "flywheel" effect for a Class B GG amplifier since the exciter is generally too electrically remote from the cathode circuit.

tx audio ac modulation

There are two recognized sources of minor ac modulation of the audio in the TS-930S SSB transmit mode. Both are sometimes elusive but curable. The first is simple magnetic coupling between the dynamic microphone element and the power transformer. To see if this is a problem, move the microphone around the radio (especially on the left side near the power transformer) and listen to the monitor for the results. To minimize the problem, relocate the microphone and use the lowest impedance possible; to eliminate it, change to a nonmagnetic element. The second problem was more elusive and difficult to isolate; W6UYW tracked it down after we spent many hours of searching. It too is audible in the monitor, especially with the microphone disconnected, and must be fixed from the inside. Its source (in serial numbers in the 3.1 to 4.0M range) is a small green rf choke called L3 on page 40 of the Owner's Manual. It is 150 μH in value installed by Kenwood to eliminate some rf feedback problems being experienced at low frequencies. Unfortunately, this choke is a solenoid type and susceptible to inductive coupling from adjacent cabling. The amount of modulation varies in each unit, depending on its orientation. By reorienting the choke, the modulation can be reduced but not eliminated. For a complete cure, place a drop of solder short it out, or replace it with a ferrite toroidal core or a bead. Find L3 by removing the bottom cover and locating a small pc board directly behind the microphone connector. This choke is not shown on all schematic diagrams. In some cases it is orange or black in color and presents no problem, as it is apparently a closed core, self-shielded design. (The usual warranty caveat applies.)

I hope this information will be useful to operators who wish to improve their transmitted SSB audio quality, and that some of the fixes described will lead to better performance from this fine equipment.

acknowledgments

I wish to thank W4CG, K5CX, W6UYW, and W0IAK for their contributions.

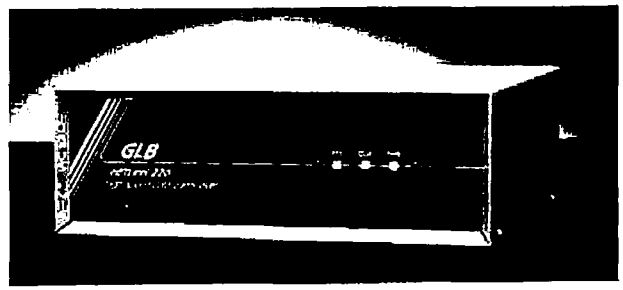
references

1. Marv Gonsior, W6FR, ""Simple Modifications and Adjustments for the TS-930S," *ham radio*, April 1987, pages 19-27.
2. Helge Granberg, K7ES, "Measuring the Intermodulation Distortion of Linear Amplifiers," Motorola RF Data Manual, second edition, 1981, pages 3-42/44.
3. Jay B. Rusgrove, W1VD, "Spectrum Analysis – One Picture's Worth a...," *QST*, August 1979, pages 15-21.
4. William I. Orr, W6SAI, "Intermodulation Distortion in Linear Amplifiers," *QST*, September 1963.
5. Dr. Ulrich L. Rohde, DJ2LR, "Digital PLL Frequency Synthesizers Theory and Design," Prentice Hall, Inc., 1983.

ham radio

NEW FROM GLB

GLB NETLINK 220
HIGH-SPEED DATA TRANSCEIVER



FEATURES

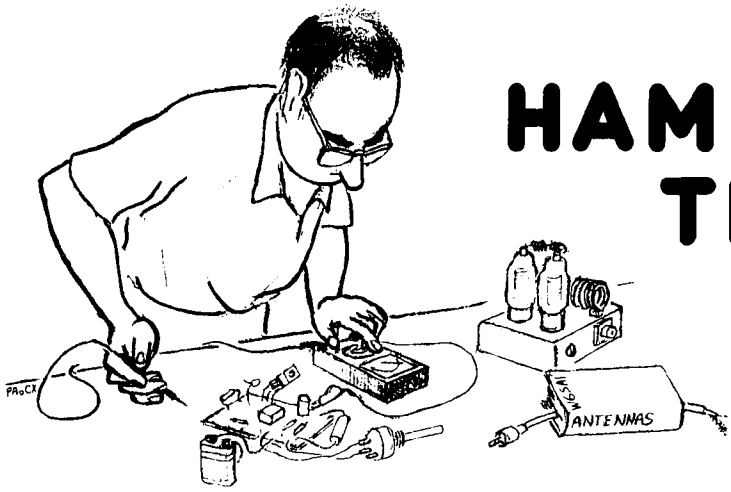
SPECIFICATIONS

See us at DAYTON Booth 318

Amateur net $ 699.95
List price $ 709.95

GLB ELECTRONICS, INC.
151 Commerce Pkwy.
Buffalo, NY 14224
716 675-6740 9 to 4

116



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

DX is getting better and better! Here's why!

DX is better this year than last, and even that was pretty good. Why this sudden improvement in conditions? Some say it's because the sunspot count is rising. Nonsense! What does the sun have to do with DX, anyway? A lot of DX comes through at night when the sun is sleeping. A study of events in the DX world provides several simple answers to this question.

First of all, the earth is shrinking. Remember Columbus? He took nearly a month to reach the New World. The Blue Ribbon liners crossed the Atlantic in a little over three days in the late "thirties". Now, you can cross the Atlantic in a little over three hours in supersonic transport! Have you ever wondered why gas mileage is getting better and better? Cars travel less distance to get to the same places, that's why. It's obvious that the earth is getting smaller every day.

Second, the ionosphere is leaving. Since radio waves pass through the ionosphere, there must be a lot of friction up there to slow things down. Scientists recently discovered a hole in the ionosphere over the Antarctic — it's leaking into space! Once it's all gone, DX conditions will be fantastic!

Third, Chicken Little said, "The sky is falling!" Obviously if the sky is falling, what's left of the ionosphere is closer to the earth. That makes for less friction and it's easier for radio waves to bounce around between DX stations.

Finally, packaging experts have done their job. While the shipping carton the radio comes in gets bigger and bulkier, the radio inside has shrunk. Just like potato chips. The bag is bigger, but there are fewer chips in the bag. The same thing can be said for candy bars and radio equipment. Today's radios are so small that the electrons can zip around in less time! Thus an S9 signal (all signals are S9 to begin with) is still S9 by the time it wends its way through all those ICs and finally reaches your eardrums!

So that's the way it is. And I don't want to hear any more foolishness from George Jacobs, W3ASK, nattering about sunspots and the ionosphere. You now have the straight information, and don't forget who told you!

good news for "low-fers"

What's a good antenna for 80 and 160 meter DX? How about a quarter-wave vertical, working against a buried counterpoise consisting of 120 radial wires, each a quarter wave long? A lot of low-fer DXers use an antenna of this type with good results. But laying several thousand feet of buried radial wires has discouraged a lot of hams who dream of owning an effective low-band vertical antenna.

Broadcasters, too, have had second thoughts about this type of antenna, a standard broadcast installation since the mid-twenties. It represented a lot of money literally placed in the ground!

Experiments conducted by Arch Doty, Jr., K8FCU; John Frey, W3ESU; and Harry Mills, K4HU, and described in the 1983 bulletin of the *Radio Club of America* showed that the traditional ground radial system (composed of a number of buried or surface wires) could be equaled or bettered by the use of an elevated ground screen about 6 feet above ground. The screen has 50 or more radials connected at their tips to form a spoked wheel about 0.4 wavelength in diameter. This could be an effective substitute for the buried radials, but it is difficult to install and quite expensive.

The next step in this ongoing investigation took place at the recent broadcast symposium of the Institute of Electrical and Electronic Engineers (IEEE). An evaluation of the performance of four elevated radial elements compared with 120 buried ones was presented by investigators from Ohio State University, Cap Cities ABC, Lawrence Livermore Labs, and the Naval Postgraduate Shool.

The report concluded that as few as four radials above the ground would provide superior performance over 120 buried radials and that power gain at low angles would be enhanced.

The experiment was conducted at 1 MHz with an antenna height and radial length of one quarter wavelength. Tests showed that skywave radiation was attenuated and power gain at low

angles was enhanced. The same procedure was employed at 3 MHz with "very similar results".

The test model antenna had radials elevated 50 inches above ground, and increasing radial length did not appreciably improve performance. Improvement when going from 4 to 120 radials "was not worth the effort of installing".[1]

The studies generally concluded that performance improvement was good for radiation angles of up to about 20 degrees, but above that the buried radials began to have better power gain. Since most 80 and 160 meter DX operation seems to be at angles of 20 degrees or lower, the above-ground radial installation seems to offer a distinct advantage for the low-fer DXers.

an inexpensive console for crowded quarters

Operating from a small apartment, motor home, or condominium has its problems. One of the most pressing ones is where to put the ham station! Operating a ham rig from a folding card table isn't much fun.

I recently received a catalog from a large mail-order house, and while browsing through it noticed several "Microwave Oven Carts". These were sturdily constructed, oak-finished carts with a top shelf for the microwave and a shelf underneath for utensils and dishes. Below that was a drawer atop a storage area behind double doors. The carts have casters for easy movement and models are available with different shelf configurations.

The smallest one, called a "Utility Cart", has two shelves and a storage space, while larger carts have more shelves. They look nice enough to be considered furniture and all are modestly priced. You could place a transceiver on the lowest shelf and a linear amplifier on top of the cart where the microwave would go. Or perhaps you might put several VHF rigs on the lower shelf and an antenna rotor and SWR meter on the top. A hundred ideas flashed through my mind as I looked at the carts.

Interested? Most large mail order stores supply these. The ones I saw are from BEST Products Corporation.

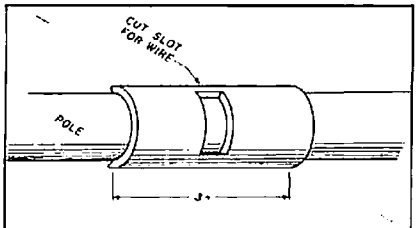


fig. 1. Short length of PVC plastic pipe is cut to fit over bamboo pole. Tubing is held in place with wire tie-wraps.

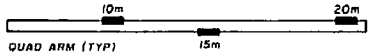


fig. 2. Wire supports shown in fig. 1 are staggered on Quad arm to distribute wire stress.

quad antenna construction

Now that 10 meters is coming back to life, there is renewed interest in the Quad antenna. You hear a lot of them on the band these days.

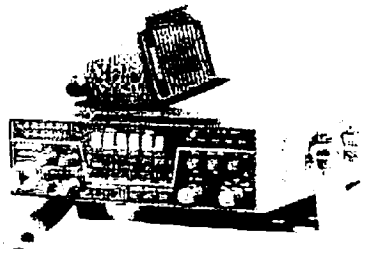
It's not hard to build a Quad, but it is difficult to construct one that will stay up in bad weather. They are floppy affairs at best, and you must put a lot of thought into the physical arrangement of the antenna if you don't want it to come crashing down in the next storm.

Lloyd Hanson, W9YCB, has some interesting ideas on Quad construction. He says the best Quad arms are made of "Calcutta bamboo" with PVC heat-shrink tubing slid over the bamboo between the joints. The end of the arm is also sealed with a short piece of heat shrink. An acceptable alternative for the Quad arm is a fiberglass drapery pole. Lloyd has found a lot of these at garage sales.

The poles should not be drilled for the Quad wires after they've been protected with heat-shrink tubing. Instead, cut a piece of PVC lengthwise to fit the pole. Cut a slot in the tubing to hold the wire and glue it to the Quad arm with PVC cement. Two wire tie-

10 METER DX IS HOT!

AND YOU CAN WORK IT WITH THE NEW RANGER AR 3500



- Convenient, easy-to-use front panel controls
- All Mode operation
- Switchable noise blanker—highly effective on ignition noises
- 100 Hz per step
- Programmable band scanning
- Five selectable memory channels
- Split frequency operation
- Easy-to-read LED frequency display
- Available in outputs of 30 & 100 watts
- Microphone and power cord supplied

RECEIVER

Frequency Range: 28.0000-29.9999 MHz
Circuit Type: Superhet, dual conversion
Clarifier Range: ±500 Hz
Sensitivity: SSB & CW better than 0.3 μV for 10 dB S+N/N. FM better than 0.5 μV
Selectivity: -6dB -60dB
SSB, CW 2.6 KHz 4.7 KHz
AM, FM 6.0 KHz 18 KHz

TRANSMITTER

Frequency Range: 28.0000-29.9999 MHz
Power Output: 30 watt Model: SSB—25 Watts. AM/FM—8 watts, CW—30 Watts
Input 12.5 VDC, 6A Max
Power Output: 100 watt Model: SSB—100 Watts. AM/FM—30 Watts, CW—150 Watts
Input 12.5 VDC, 25A Max

WARRANTY

Limited one year warranty by Clear Channel Corporation of Issaquah, WA.

AR3500-30W (Reg. 359).....Call Us
AR3500-100W (Reg 449).....Call Us
Scan Mic & Mod installed.....$45.00
SP-1 Speech Processor.....33.00
CW Bd. Auto break-in.....39.95
3 Element Beam 26-30 MHz.....89.50
Penetrator Mobile Ant.....44.95
RS-7A Pwr Sup for 30W.....49.95
RS-35A Pwr Sup for 100W.....134.95

SEE YOU AT DAYTON BOOTH 360

Quantity Pricing Available Foreign Orders Accepted
Orders received by 1 PM PST shipped UPS same day.
COD VISA MC Next day UPS delivery available
ORDER DESK ONLY — NO TECHNICAL
(800) 854-1927
ORDER LINE and/or TECH HELP
(619) 744-0728
FAX (619) 744-1943

RF PARTS COMPANY
1320 Grand San Marcos
California 92069

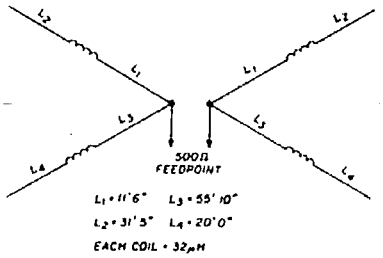


fig. 3. The Austin-Fourie wideband antenna covers 3.30 MHz with SWR less than 2.5-to-1.

wraps will hold it securely after the glue has dried (fig. 1).

Lloyd staggers the Quad wire supports on each side of the arm to distribute the stress more equally (fig. 2). He uses two smaller booms, spaced about one foot apart as supports because a single boom for a four element Quad will not stand the gaff in bad weather.

a wideband "dipole" antenna

Bill Wildenhein, W8YFB, called my attention to an interesting antenna developed by Dr. Brian Austin and Andre Fourie of the University of Liverpool and described in the September, 1987 issue of *Electronics and Wireless World* published in England. The design functions from 3 to 30 MHz with an SWR of 2.5:1 or less over that range (fig. 3).

The antenna consists of two coil-loaded dipoles fed in parallel. A 32-μH loading coil is placed in each dipole half, as shown in the illustration. The angle between the dipoles is not specified.

The feedpoint impedance is about 500 ohms, so the antenna could be fed with a 50-ohm line and a 10:1 balun.

It would be interesting to try this unique antenna in an inverted-V arrangement and run an SWR curve across the operating range. Any takers?

antennas for the 24.9-MHz band

Need a quick design for a beam antenna for this band? Simply take an applicable 6-meter beam (50 MHz) and multiply all important dimensions by 2!

references

1 *Radio World*, a publication of Industry Marketing Advisory Services, Inc., 5827 Columbia Pike, Suite 310, Falls Church, Virginia 22041, October 15, 1987.

ham radio

A better way to design and analyze Long wires, Vee's, and Rhombics.



LONG WIRE PRO

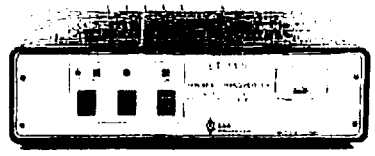
Easy to use, menu driven, select wire length, height, frequency, ground type, and get a color coded sinusoidal projection of your HF antenna. For the IBM PC and compatibles, DOS 2.0 or higher, 256K, color required.

Price $35.00

EPSILON CO

Box 715, Trumbull CT, 06611, (203) 261 7694

121



SSB ELECTRONIC TRANSVERTERS & PREAMPLIFIERS

LT33S	902/144 Xvrtr 20W GaAsfet	$599
LT23S	1296/144 Xvrtr 10W GaAsfet	$599
MICRO 13	2304/144 Xvrtr 0.5W GaAsfet	$419
MICRO-X	10,368/144 Xvrtr 200mw GaAsfet	$649
new products		
SP-2	144-148 Mhz RF switched preamp	$209
SP-70	430-440 Mhz RF switched preamp	$209
LT13S	2304/144 Xvrtr 5W GaAsfet	$599
other items		
1144/28	144 Mhz transverter 25W 28 or 50 IF	$229
1220/28	220 Mhz transverter 15W 28 or 50 IF	$249
PA 33200	902 Mhz 200 Watt PA	$549
PA 23150	1296 Mhz 150 Watt PA	$469
PA 23200	1296 Mhz 200 Watt water cooled PA	$299
PA 1325	2304 Mhz 25 Watt PA	$439
HF 400	High Power Relay 2 KW at 144 Mhz	$139
HF 2000/6	Relay 2 KW at 100 Mhz, 400 W at 6 Ghz	$219

Factory Authorized Dealer for SSB Electronics for North America

TRANSVERTERS UNLIMITED
BOX 6286 STATION A
TORONTO, ONTARIO
CANADA M5W 1P3
(416) 759-5562

TRANSVERTERS UNLIMITED (US)
P.O. BOX 178
NEW BOSTON, NH 03070
(603) 547-2213

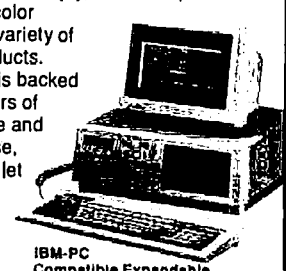
122

Free
Famous hi-tech catalog

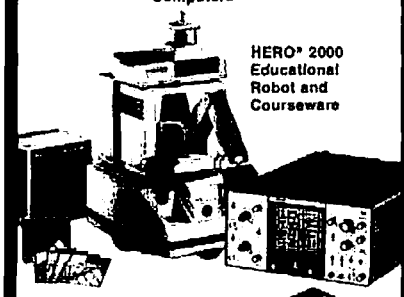


A very special guide to what the exciting world of computer and electronics kit-building can do for you.

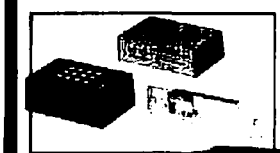
The informative Heathkit Catalog shows you more than 450 exciting electronic products that will challenge, instruct, and entertain you. You'll find countless kits that you can build and enjoy, from computers and robots to color tv's and a variety of home products. And each is backed by our years of experience and our promise, "We won't let you fail."



IBM-PC Compatible Expandable Computers



HERO® 2000 Educational Robot and Courseware



Precision Test Instruments

Electronic Keyless Doorlock



PackKit Multi-Mode TNC



Send NOW for your FREE Heathkit Catalog.

Send to: Heath Company, Dept. 122-622
Benton Harbor, Michigan 49022

Name _____

Address _____

City _____ State _____ Zip _____

A subsidiary of Zenith Electronics Corporation CL-784R3

Heathkit®
Heath Company

123

frequency synthesis up to 2 GHz

Try these ideas for the 23- and 13-cm bands

Digital frequency synthesis in the Gigahertz and higher range offers output frequency stability equal to that of the reference crystal and better than that available from dielectric resonator oscillators (DROs). This article describes a simple, low-cost synthesizer built around a Plessey PLL programmable frequency synthesizer IC. The circuit provides a frequency source for use in a variety of applications including a local oscillator and the input for a frequency multiplier. My hope is that the basic circuit will encourage experimentation with more sophisticated frequency loading methods such as from microprocessors or computers.

circuit description

The heart of the circuit shown in **fig. 1** is the SP5051/DG synthesizer. With a 4.0-MHz reference crystal, the SP5051 synthesizes frequencies between 64 MHz and 2.048 GHz, with a 125-kHz minimum step size. The reference crystal frequency is divided by 64 and then by 16 to provide a 3.90625-kHz reference frequency. The VCO output is applied to a divide-by-32 prescaler with a *minimum* sensitivity of 100 mV at 2 GHz. The prescaler output is applied to the programmable multi-modulus divide-by-M counter. When the loop is locked, the M counter provides an output which is frequency- and phase-locked to the 3.90625 reference frequency. The pin configuration of the SP5051 is shown in **fig. 2** and a block diagram is shown in **fig. 3**.

The divide ratio is specified using 16-bit serial data entry, where 14 bits drive the programmable M counter and the two most significant bits specify the control select outputs. Data bits are loaded into the storage register on the low-to-high data clock transition only when the chip select input is also high. Chip select should be timed to go high during the low period of the data clock to prevent false data loading. **Figure 4** shows data format and timing requirements. In the circuit shown in **fig. 1**, LEDs are tied to the control outputs to demonstrate their state; in actual practice, these outputs might be used to select alternate band VCOs or to control LNA polarity. **Table 1** shows control select data versus the control output states.

Because the SP5051 is a 5-volt device, an external NPN transistor is driven by the charge pump output, providing the 0- to 30-volt swing necessary to drive the variable capacitance diode in the VCO. During data entry, the charge pump output is disabled by the chip select signal, thereby preventing the generation of spurious output frequencies. The output of the M counter may be monitored at pin 12 at ECL voltage levels if a 6.8-k resistor is connected between pin 12 and ground.

As in the entire SP5000 family of synthesizers, the SP5051 uses mixed ECL and I^2L technologies on the same substrate. Separation of the +5 volt and ground supplies reduces the interaction between circuit sections, but it requires that all supply pins be connected and that both +5 VDC lines be decoupled with quality capacitors near the device itself.

the VCO

While there are several excellent commercial VCOs available in the desired 1.5- to 2-GHz range (including the Avantek VTO 8150, for example), prices in the $100 area preclude their use in low-cost applications. The design shown in **fig. 1** was developed using BB405 TV tuning diodes (2 pF at 25 volts, 16 pF at 1 volt) and a standard Siemens BFR34A transistor. The cost of both components is just a few dollars.

By Douglas R. Schmieskors, Jr., WA6DYW, 4633 Old Ironsides Drive, Suite 250, Santa Clara, California 95054

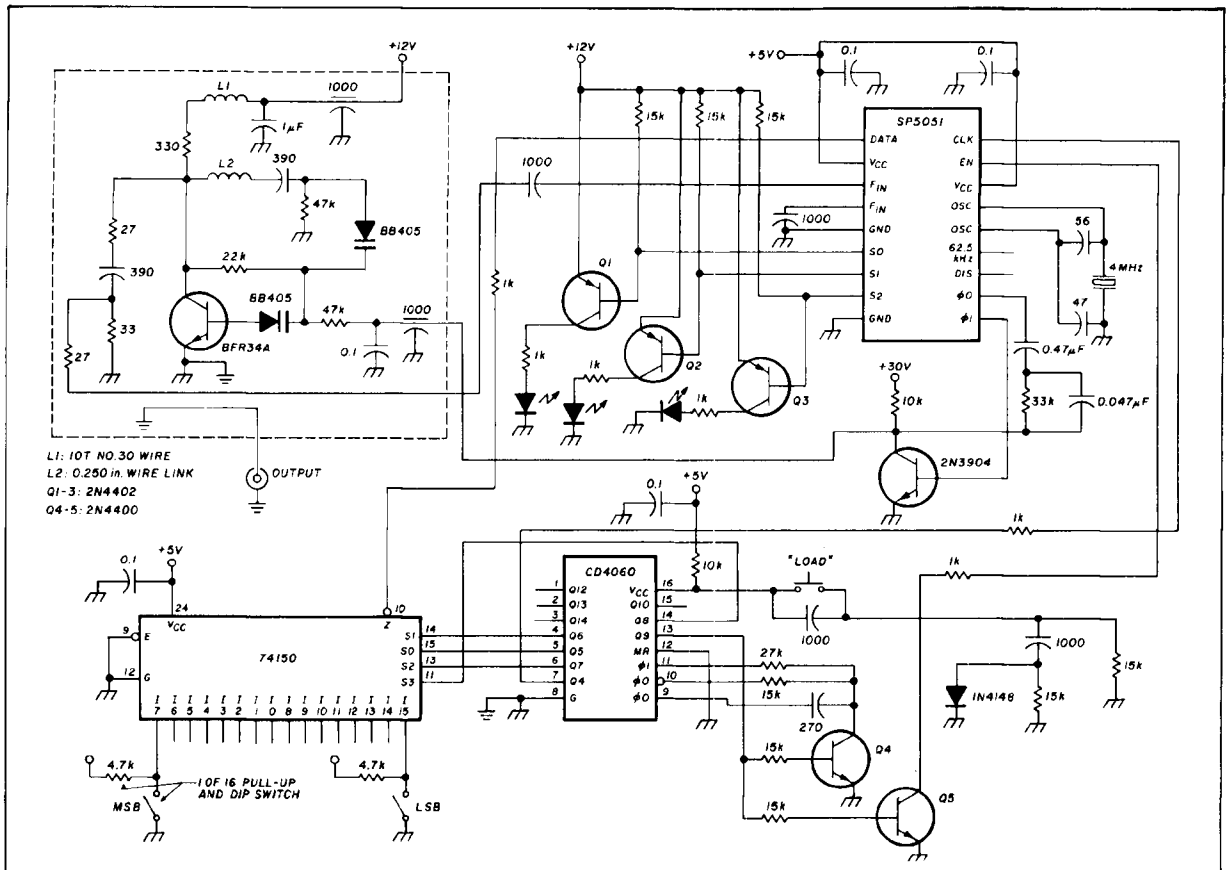


fig. 1. Demonstration circuit.

Table 1. Control select decoding

Control select data		Control outputs pin		
2^{15}	2^{14}	6	7	8
0	0	H	H	H
0	1	H	L	H
1	0	L	H	H
1	1	H	H	L

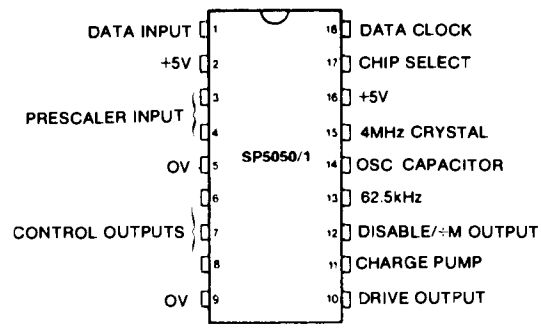


fig. 2. Pin connections — top view.

In fixed frequency oscillators, the resonant circuits and decoupling capacitors would be made by using sections of transmission line, but the frequency variation required in this VCO requires the use of conventional components. The series inductance of most capacitors at 2 GHz becomes a major portion of the resonator circuit, and unless care is used in the layout, decoupling is degraded.

The tuning voltage from the 2N3904 is applied through a 47-k resistor to the variable capacitance diodes. These diodes form a series-resonant circuit with the 0.250-inch wire link and the various lead inductances. The 390-pF capacitor provides dc isolation from the collector decoupling, while the 330-ohm resistor also provides some feedback to help stabilize the bias. The 22-k resistor laid directly across the transistor from base to collector sets the bias at about 15 mA, while the emitter is soldered directly to ground to prevent emitter decoupling problems.

Output is coupled from the collector using a 27-ohm

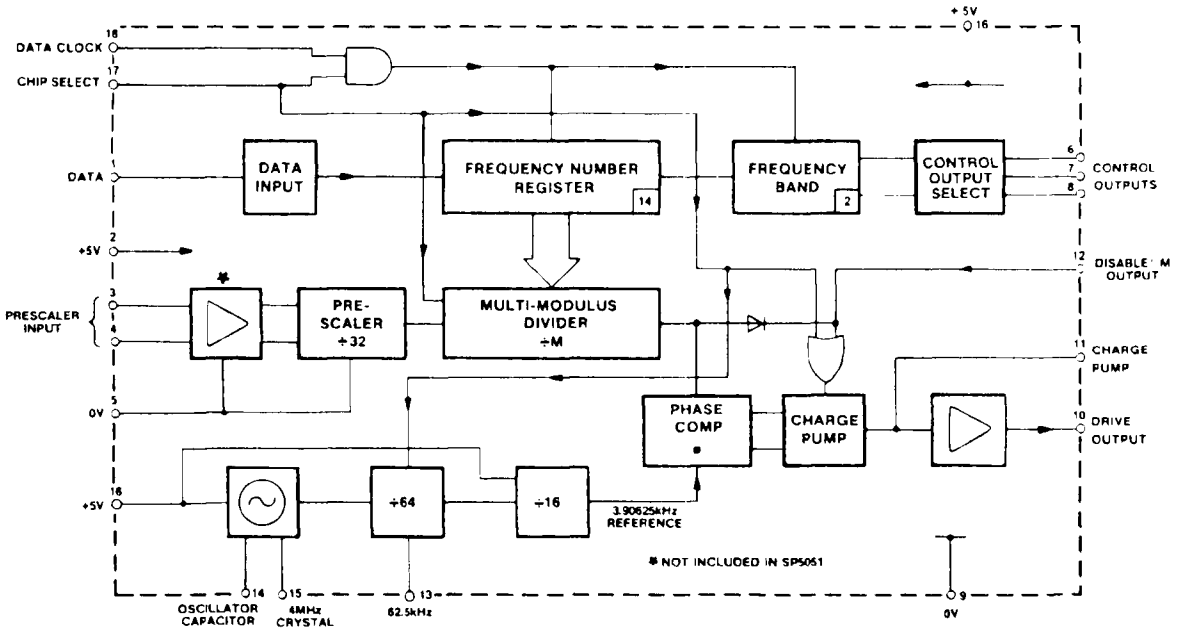


fig. 3. SP5050/1 block diagram.

DRSI

DIGITAL RADIO SYSTEMS, INC.

The next era in Packet Radio is just over the Horizon

126

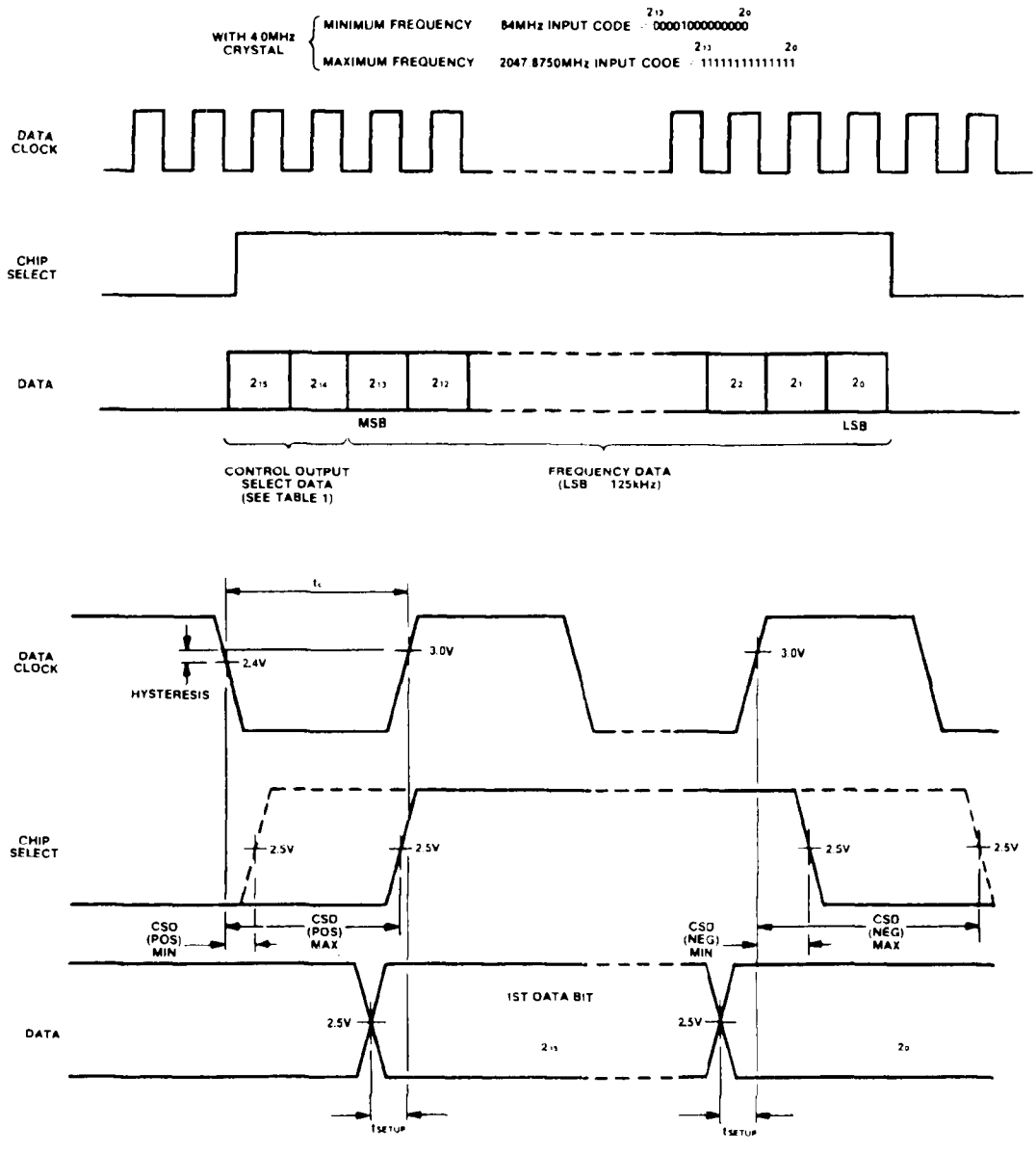


fig. 4. Data format and timing.

resistor and another 390-pF capacitor, while a 33-ohm and a second 27-ohm resistor act as an attenuator prior to the synthesizer input. A coupling link is used to tap off some of the output for connection to a spectrum analyzer or counter.

Standard G10 fiberglass circuit board was used, but board capacitance prevented mounting the resonance-determining components on the board. Teflon™ board would undoubtedly make the oscillator more stable and easier to assemble. Layout with the fiberglass board is critical, and component lead lengths are kept as short as possible by mounting above the board surface.

operation

In most applications, the SP5051 would be supplied with frequency data by a microprocessor, but because a simple, stand-alone frequency source was desired, an extremely simple and unsophisticated circuit was designed to allow data entry from dip switches. The

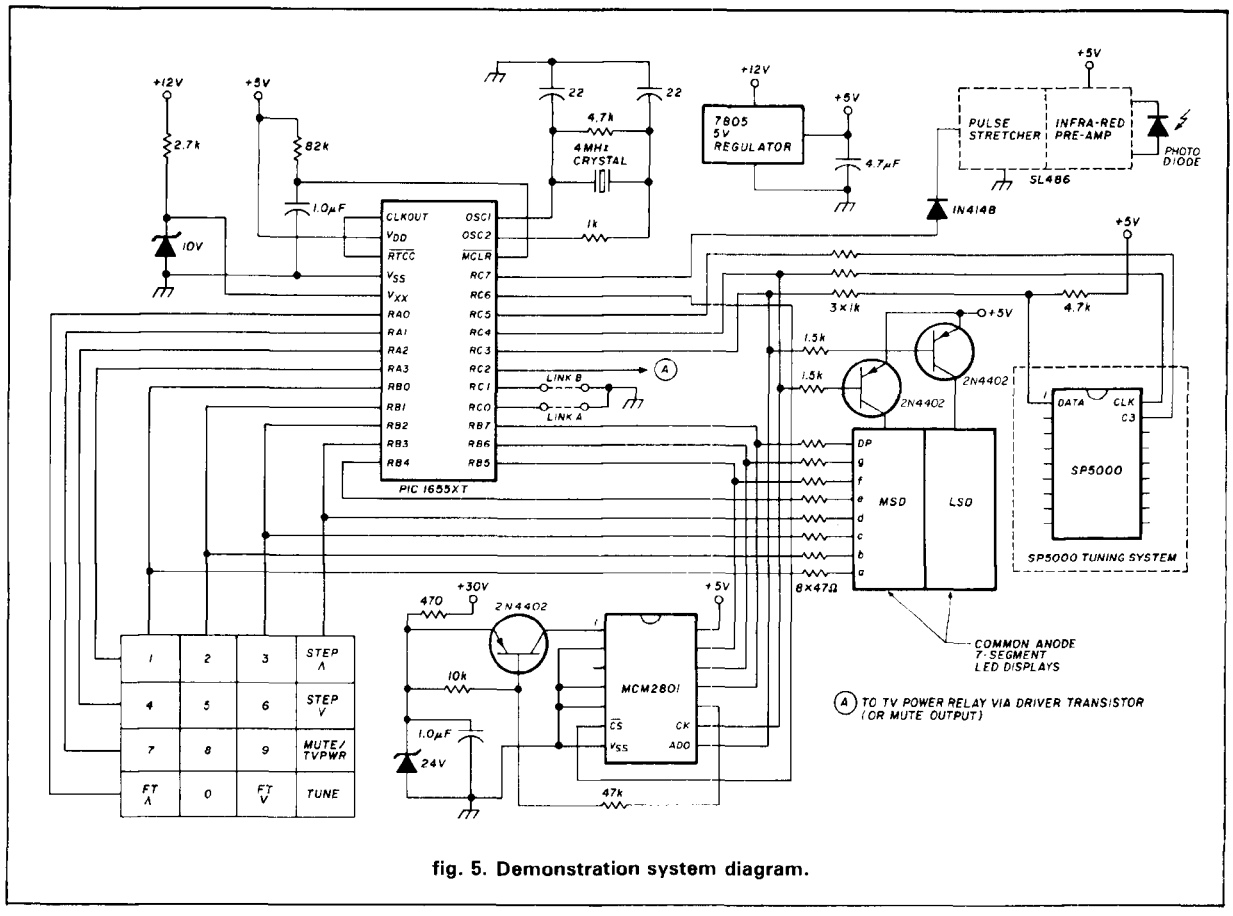


fig. 5. Demonstration system diagram.

data clock for the SP5051 is taken from the Q4 output of the CD4060 14-stage counter-oscillator. The 74150 16:1 multiplexer is sequenced by the Q5-Q8 counter outputs and data from the multiplexer output is applied to the SP5051 data input. The Q9 output of the 4060 provides chip select to the SP5051. Closing the push-button switch causes the word programmed by the dip switches to be entered into the SP5051.

different reference frequencies

The SP5051 is specified to operate with a reference crystal frequency of 2 to 7 MHz. With 200 mV input to the prescaler, the SP5051 has been found to operate to more than 2.5 GHz. To determine a new reference crystal frequency, f_R

$$f_R = \frac{f_{MAX}}{512}$$

and

$$f_{STEP} = \frac{f\,MAX}{2048} \cdot 125$$

where f_{STEP} equals the new minimum step size in kHz and f_{MAX} equals the desired maximum frequency in MHz. Thus, the maximum operating frequency or the minimum step size may be varied within the reference crystal and maximum input frequency ranges of the device.

Another version of the SP5000 family, the SP5060/DG, offers a fixed frequency output of 1.024 GHz based on a 4.0-MHz reference crystal. No data, enable, or clock inputs are required. It can be seen from the formulas above that about 1.8 GHz maximum can be obtained with the SP5060 and a 7-MHz crystal. Other versions of the SP5000 family offer higher input sensitivity, fixed frequency outputs for up-conversion to standard TV channel frequencies, and smaller step sizes.

A very generalized idea for adding microprocessor control, LED frequency display, and remote control to an SP5051-based tuning system is shown in fig. 5. The processor drives the LED segments directly, and buffer transistors are used to enable the LED anodes. The desired operating frequency is entered into the processor from either the local or remote keyboard, and the look-up table then provides the correct serial word to the synthesizer.

ham radio

amateur packet radio
networking and protocols: part 3

Packet radio protocols past and present

This is the last in a three-part series on the inner workings of Amateur packet radio. Part 1 introduced networking and protocols and included a discussion on the OSI/RM (Open Systems Interconnection Reference Model). Part 2 explored the first two layers of the OSI/RM and their applications to Amateur packet radio and examined the AX.25 level 2 packet radio protocol.

Part 3 concludes our look at the second OSI/RM layer with a discussion of other data link layer packet protocols. Also covered are the remaining OSI/RM layers. Special attention is paid to the network layer as current packet radio protocol development centers around networking.

data link layer

The V-1 protocol, commonly known as the VADCG protocol, was developed in 1979 by Doug Lockhart, VE7APU. That summer, Doug was working on a protocol for the VADCG (Vancouver Amateur Digital Communications Group) TNC (Terminal Node Controller) for use with a master station and multiple TNCs. The TNCs would connect to the station node where they would be assigned numeric addresses, and all communications between users would take place through this node.

A packet group in Hamilton, Ontario was working on developing TNCs and wanted a protocol that allowed the TNCs to be connected to each other directly rather than by way of a station node. Doug was asked if he could provide such a protocol which would free them to experiment with the TNCs and eliminate the need to set up a station node first.

Doug modified the protocol he was using by eliminating dynamic addressing and other facilities employed by the station node. The end result was a simple protocol allowing TNCs to connect directly to each other -- a kind of kludge to meet a specific request. This temporary experimental protocol (called the VADCG-1 or V-1 protocol) gained popularity and eventually came to the United States when it was distributed with VADCG TNC kits. Doug has since completed a second VADCG protocol.

Though it was never Doug's intention, the V-1 protocol achieved popularity in the United States and became a packet radio standard because it was the only one around that actually worked.

The VADCG protocol used in the United States was not identical to the one Doug developed for the Hamilton packet operators. The protocol, as it was first used in Canada, allowed for up to 254 numeric addresses and each station would have one assigned beforehand. When Hank Magnuski, KA6M, put the United States' first all-digital simplex packet repeater (now called a digipeater) up in California on December 10, 1980, he used a modified version of the VADCG protocol. A portion of the address space was used to support digipeater control, thus reducing the total number of user addresses from 254 to 32.

The modified version of VADCG protocol used in California became the standard in the United States. Doug was approached several times about making the protocol an international standard, but he consistently resisted this as he saw VADCG as a temporary "testing" protocol too limited for widespread use. These limitations would later cause packet groups in the United States to develop alternate data link level protocols such as AX.25.

By Jonathan L. Mayo, KR3T, 3908 Short Hill Drive, Allentown, Pennsylvania 18104

The protocol had only two commands: connect and disconnect. To connect with another station, the user would type his callsign and a CTRL-X. A connect request frame would be sent containing the other station's call, the user's call, and the user's VADCG numeric address. The other station would respond with an acknowledgement including this numeric address and all information frames would then be sent with only the VADCG addresses. To disconnect, the user would type a CTRL-Y and a disconnect request would be sent. Once the disconnect request was acknowledged, the connection was terminated.

The VADCG protocol is still in limited use in Canada and Australia. It is similar to HDLC (High-level Data Link Control) in that numeric addresses are used. Because it is no longer widely used and of limited benefit to most packet operators, a detailed explanation of this protocol is not provided.

second VADCG protocol "V-2"

Doug Lockhart has continued developing link level protocols because, for various technical reasons, he does not feel that AX.25 is a viable link level protocol for the large scale development of packet radio. His second VADCG protocol, V-2, offers many improvements.

V-2 allows both full and half-duplex links. Multiple links are maintained along with some multiple protocol support. The number of numeric addresses has been significantly increased, and addresses need no initial coordination.

When the second protocol's specifications were published, TAPR (Tucson Amateur Packet Radio) compared them with the AX.25 protocol and found some notable variations but not enough to require changes in the current link level protocol. Some differences are: *reduced address space, differentiation between user names (callsigns) and node addresses (numeric identifier), and no "network level" functions.* V-2 is similar to SLDC, HDLC, AX.25, and V-1. It is designed to be implemented along with upper level protocols to establish a complete network.

other level 2 protocols

Several data link layer protocols have been used in Amateur packet radio. Two Canadian groups besides the VADCG developed viable packet systems with protocols and TAPR had its own data link layer protocol prior to the adoption of AX.25.

The Montreal group was using a combination COP/BOP (Character Oriented Protocol/Bit Oriented Protocol) with ASCII characters as frame delimiters. This system was operational in 1978 running at 4800 baud AFSK on 220 MHz.

The second Canadian group, based in Ottawa, used a polling protocol and was the first to develop the concept of a digipeater. Their system was running at 9600 baud FSK in 1980.

TAPR had a data link level protocol up and running shortly after their startup. Known as TAPR/DA (TAPR/Dynamic Addressing), this protocol was being implemented before the 1982 AMSAT/AMRAD protocol conference and was one of those considered. It was passed over in favor of AX.25.

networking

Current work in the United States is directed at level 3 network layer protocols. There are several systems under development today and most are based in level 3 of X.25.

The RATS (Radio Amateur Telecommunications Society) group in New Jersey is experimenting with one system; another is being developed by the FADCA (Florida Amateur Digital Communications Association) group. Right now these systems simply acknowledge packets being repeated through them (replace the end to end ACK of AX.25 with a point to point ACK), but they should soon contain routing tables that will automatically select the best route for a packet to reach its destination, transparently to the user.

Another more recent networking system is NET/ROM developed by Ron Raikes, WA8DED, and Mike Busch, W6IXU. This protocol simply replaces the ROM (Read Only Memory) chip in any TNC-2 compatible TNC (Terminal Node Controller) and makes it a network node. Users can connect to other NET/ROM nodes as well as conventional stations with the benefit of point to point ACKs through the NET/ROM nodes. It also maintains routing tables to other NET/ROM nodes, so it is not necessary to specify a path between nodes.

TAPR's latest project is a *Network Node Controller* (NNC) — a combination hardware and software device designed to serve as a network node in an Amateur packet network. It is actually a small but powerful computer system complete with microprocessor, memory, and external storage. There are four HDLC ports with flexible characteristics.

For instance, two ports might be configured for Bell 202 use on VHF, a third for 9600 baud on UHF, and a fourth for Bell 103 on hf. Thus a user may connect to the NNC on one port and route his packets out one of the others (this may be handled automatically by the NNC's software). The NNC will acknowledge frames as they are received (a point to point acknowledgment).

network layer sublevels

The network layer (level 3) is usually divided into two distinct sublevels: 3A and 3B. Level 3A is controlled by the INTRAnet protocol and 3B by the

INTERnet protocol. INTRAnet deals with communications around a single network node and user stations while INTERnet takes care of communication between network nodes.

Communications between individual users and their network node (INTRAnet) will probably be through *virtual circuits*. A virtual circuit is a method of connecting stations using an abbreviated address field once a connection is established. The stations must be connected before commmunications can begin, and the addressing information contained in each transmission is decreased after the connection is made. The lack of complete addressing information forces each packet to take the same path through the network.

INTERnet communications are still under debate--they may be virtual circuits or datagrams. A *datagram* is a method of connecting two stations in which each packet sent over the network contains complete addressing information. Their advantage is that they may be dynamically routed through the network (i.e., the path of the connection may change) because they contain complete addressing information. The advantage of virtual circuits is that once the connection is established, the amount of packet space consumed by the address field can be significantly reduced.

Virtual circuits require more reliable, intelligent network nodes to "remember" the path of the connection. Datagrams may reach their destination despite failure of one or more network nodes by being dynamically routed around the nonfunctional ones. Once network nodes are fully implemented, a user from one area of the country can access a node and connect to any other station that the network reaches (similar to the telephone system).

transport and session layers

OSI/RM Levels 4 and 5 have also been under development for use in Amateur packet radio. A popular contender for the level 4 transport layer is TCP (Transmission Control Protocol). TCP is generally regarded as a complex protocol for dealing with inadequate or unreliable lower layer protocols. TCP also handles the session layer (level 5). Phil Karn, KA9Q, has developed a TCP implementation for packet radio use that can be run on microcomputer systems.

presentation layer

The presentation layer (level 6) is also getting some attention. The NAPLPS (North American Presentation Level Protocol Syntax) graphics protocol provides a means for graphics transmission via packet radio. Other possibilities are FTP (File Transfer Protocol) and SMTP (Simple Mail Transfer Program).

application layer

The application layer is the seventh and final OSI/RM level. At this time, there are no true application layer protocols or systems operating or being developed for Amateur packet radio.

conclusion

To recap, we have finished our discussion of the OSI/RM applications to Amateur packet radio. Keep in mind that the OSI/RM provides an excellent frame of reference for designing a network, but is not cast in stone. Future Amateur packet radio operations might handle high-level protocols differently, but for now appear to be proceeding according to the OSI/RM.

This three part series has covered most aspects of Amateur packet radio networking and protocols. Although some of the concepts may be confusing, in-depth knowledge of networking and protocols is not a prerequisite to operating and enjoying packet radio.

If you have any questions or comments, write to me at the address listed or leave a message on CompuServe; my User ID is 72276,2276.

Portions of this series are from my book, *The Packet Radio Handbook,* available from the *ham radio* Bookstore for $14.95 plus $3.50 shipping and handling.

ham radio

K.V.G. CRYSTAL PRODUCTS



9 MHz CRYSTAL FILTERS

MODEL	Application	Bandwidth	Poles	Price
XF-9A	SSB	2.4 kHz	5	$61.00
XF-9B	SSB	2.4 kHz	8	89.00
XF-9B-01	LSB	2.4 kHz	8	125.00
XF-9B-02	USB	2.4 kHz	8	125.00
XF-9B-10	SSB	2.4 kHz	10	165.00
XF-9C	AM	3.75 kHz	8	89.00
XF-9D	AM	5.0 kHz	8	89.00
XF-9E	FM	12.0 kHz	8	89.00
XF-9M	CW	500 Hz	4	62.00
XF-9NB	CW	500 Hz	8	145.00
XF-9P	CW	250 Hz	8	175.00
XF-910	IF noise	15 kHz	2	21.00

10.7 MHz CRYSTAL FILTERS

WRITE FOR FULL DETAILS OF CRYSTALS AND FILTERS
Export inquiries invited — Shipping: $3.75

ANTENNAS

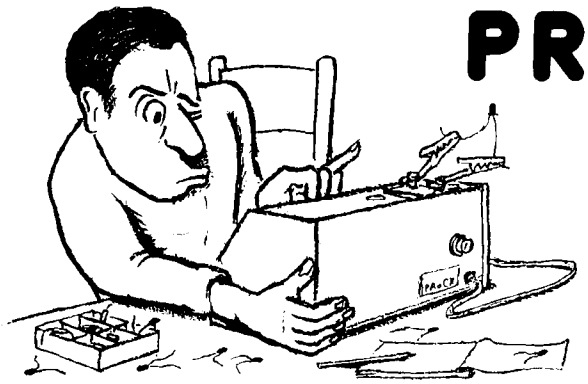
2M			
10XY-2M	$93.00	LOOP YAGIS	
70cm		1268-LY	$60.00
70MBM28	65.00	1296-LY	60.00
70MBM48	90.00	1691-LY	70.00
70MBM88	135.00	order loop yagi connector extra	
DY20-900 MHz	99.00		

Send 66¢ (3 stamps) for full details of all our VHF & UHF equipments and KVG crystal products
Shipping: FOB Concord, Mass
Prices subject to change without notice

MasterCard VISA

Si **(617) 263-2145**
SPECTRUM INTERNATIONAL, INC.
Post Office Box 1084
Concord, MA 01742, U.S.A.

138



PRACTICALLY SPEAKING

Joe Carr, K4IPV

using the digital frequency counter: some pitfalls

The **digital frequency counter** has replaced earlier methods for measuring transmitter frequency. When used correctly, the counter gives nonambiguous readings at the press of a microphone button. Previous methods required operating dials, and, often as not extensive interpolation between dial points using subharmonics of the actual frequency meter reading. As might be expected, accuracy suffered on higher frequencies. When digital counters first made their appearance in the late 1950s and early 1960s they were extremely expensive. The first digital frequency counter that I can recall was a Motorola unit designed for use by their franchised communications shops. Priced at $4,800 the counter would operate only to 500 MHz.

The modern digital frequency counter is based on modern large scale integration (LSI) monolithic chips which make them much cheaper than earlier versions. On my home workbench there is a 600-MHz counter with specifications that make it legal for use in checking Citizen's Band transmitter frequencies (0.005 percent for CB transmitters). The price? At retail I paid $129 and saw it for $30 less (brand new) at hamfests just last year. Expect to pay a bit more for a model with a temperature compensated crystal oscillator (TCXO) in the timebase, but I have seen a 600-MHz TCXO counter for less than $400. Like many electronic products, the performance is about the same as it was 20 years ago, but the price tag is significantly less. Consequently, the digital frequency counter is well within the means of many Amateurs, and should be a part of their workbench test equipment.

Another feature of the little DFC on my bench is its size and weight. Older versions of these instruments were heavy and large. The Motorola was state of the art in its day, but that was another era. It was "portable", but I can attest to the fact that "portable" didn't include carrying it up many flights of stairs to a rooftop repeater site! The 600-MHz counter I now use fits inside a winter coat pocket with space left over. At least three companies sell handheld counters sufficient for most Amateur radio applications.

One problem with digital frequency counters is that erroneous readings can result if they are used improperly. After describing some of the counter's specifications, we will take a look at possible situations where even the best instruments will yield bad readings.

This article assumes you are familiar with the basics of digital counter circuits. A future column will look at various digital counter circuits and schemes, but for now we will deal with the instrument as a "black box", instead of looking at the internal circuitry. We will, however, examine the block diagram of the digital frequency counter.

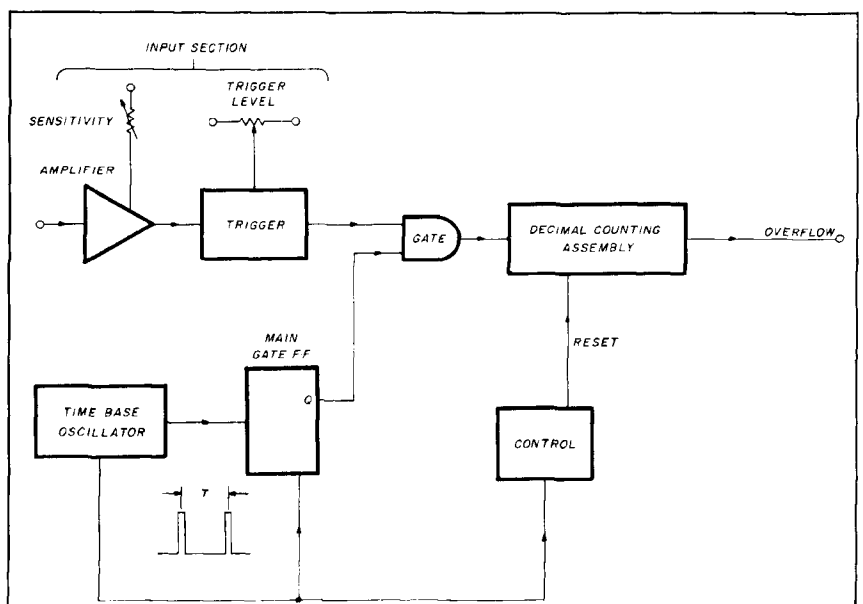


fig. 1. Block diagram of a digital frequency counter.

digital frequency counters

Figure 1 shows the block diagram of a typical digital frequency counter. Remember that the definition of frequency is events per unit of time (EPUT). There are five main sections to the counter: Input Section (consisting of the input amplifier and trigger circuit), Main Gate, Decimal Counting Assembly, Timebase, and Control Section.

The *Input Section* acquires the signal and shapes it as needed by the digital circuits. This signal is anything from a simple sine wave to a highly complex waveform with high harmonic content. The input amplifier is designed to boost the level to a point where it can drive the trigger circuit, which shapes the signal into a single binary pulse for each cycle. The counter circuits are binary digital circuits, and will not operate properly when a sine wave or most other waveforms are applied. The trigger circuit is absolutely necessary to the proper functioning of the counter, and it is here that some of the problems occur.

In some UHF and up counters, the input section also contains a frequency divider to reduce the input signal frequency by a preset amount to a range that is compatible with the counter circuits. These stages are common in 1.3-GHz counters. Some dividers are an easy to use 10:1, while others are 2:1 or 5:1 (requiring some mental calculations).

The *Decimal Counting Assembly* (DCA) is the actual counter. Consisting of binary counters connected in divide-by-10 (decimal) configuration, and decoders/numerical displays, the counter increments one count for every input "event". The number of decades (digits) sets the counter's resolution.

The *Control Section* keeps the circuit operating properly. It resets the DCA to zero, and synchronizes the operation of the gating circuit.

The *Timebase Section* sets the "per unit of time" portion of the equation. This circuit produces a periodic output pulse to the *Main Gate* flip-flop, which in turn controls the *Main Gate*. The gate allows pulses into the decimal counter assembly for only a specified period, T. No other section of the frequency counter bears more responsibility for accurate operation under normal conditions than the timebase. Timebase quality is the main difference between lower priced counters and premium "commercial" or "professional" counters.

The timebase section is made up of a crystal-controlled oscillator operated at some frequency (1 MHz, 4 MHz, 10 MHz, etc.) higher than the output pulse rate required. The output of the crystal oscillator is frequency divided down to 10 Hz (0.1-second timebase) or 1 Hz (1-second timebase). When these frequencies are used to control the gate, pulses are allowed into the DCA for either 100 milliseconds or 1 second; the displayed reading is therefore events per 100 milliseconds, or events per second. In general, the frequency of the input signal is:

$$Frequency = \frac{Counts\ on\ DCA}{Time\ (sec)}$$

trigger circuits

The input signal is rarely a clean square wave at the level required for proper operation of the counter's digital circuits. The signals may be too low in amplitude, or too noisy. The input signal is passed through at least two signal processing stages: an amplifier and a trigger circuit. The amplifier increases the signal from a low level to the 500 to 1000 millivolts typically required to operate the trigger circuits.

The trigger is used to produce a square wave or pulse wave output from a sinusoidal or irregular waveform input signal. The usual trigger stage is the Schmitt trigger. This type of circuit has a built-in hysteresis that is used to shape the waveform. **Figure 2** shows normal operation of the Schmitt trigger on a sinusoidal waveform (operation is similar on non-sine waves). The output of the trigger circuit snaps HIGH when the input signal crosses a preset UPPER LIMIT threshold in a positive going direction,

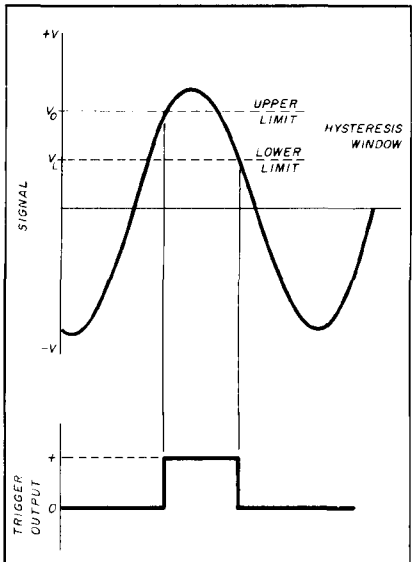


fig. 2. Properly functioning trigger circuit produces a pulse.

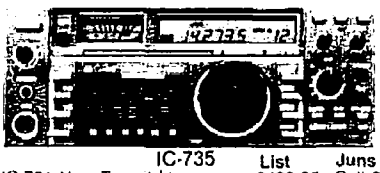
and remains HIGH until the input signal drops below the lower limit threshold in a negative going direction. The direction of signal change is an important part of the definition for this circuit's operation.

The hysteresis window shown in **fig. 2** is a critical parameter for correct counter operation, and is equal to V_U-V_L. Incorrect setting of this window can cause erratic or erroneous counter operation. It is a fundamental rule that the input signal must cross both hysteresis limits before a "count" can occur. Some counters have trigger circuit controls allowing the user to position the window and/or set its width.

Figure 3 shows three conditions in which different settings of the hysteresis window are used. In **fig. 3A** we see a correctly adjusted trigger — both limits are crossed by the input signal, so counting occurs. But in **fig. 3B** the same signal has a dc offset component, the window remains the same, and no counting occurs. This situation occurs especially in low-cost counters that don't allow adjustment of the trigger controls. Finally, we have **fig. 3C** in which the trigger control is set to position the hysteresis window below the signal, again resulting in no counting.

800-882-1343

ICOM



IC-735	List	Juns
IC-761 New Top of Line	2499.00	Call $
IC-735 Gen. Cvg. Xcvr	$999.00	Call $
IC-751A Gen. Cvg. Xcvr	1649.00	Call $
R7000 Gen. Cvg. Rcvr.	1099.00	Call $
R71A Gen. Cvg. Rcvr.	949.00	Call $
IC-28A/H FM Mobile 25w/45w	429/459	Call $
IC-37A FM Mobile 25w	499.00	Call $
IC-900 Super Multi-Band Mobile	589.00	Call $
IC-04AT UHF HT	449.00	Call $
IC-48A UHF 45w	459.00	Call $
IC-38A FM Mobile 25w	459.00	Call $
IC-02AT FM HT	399.00	Call $
IC-μ2AT Micro HT	329.00	Call $

KENWOOD



TS-440S/AT

TS-940SAT Gen. Cvg. Xcvr.	$2249.95	Call $
TS-430S Gen. Cvg. Xcvr.	819.95	Call $
TS-711A All Mode Base 25w	899.95	Call $
TR-751A All Mode Mobile 25w	599.95	Call $
TS-440S/AT Gen. Cvg. Xcvr	1199.95	Call $
TM-2530A FM Mobile 25w	429.95	Call $
TM-2550A FM Mobile 45w	469.95	Call $
TM-2570A FM Mobile 70w	559.95	Call $
TH-205 AT, NEW 2m HT	259.95	Call $
TH-215A, 2m HT Has It All	349.95	Call $
TH21BT 2M HT	259.95	Call $
TH31BT 220 HT	269.95	Call $
TM-3530A FM 220 MHz 25w	449.95	Call $

YAESU



FT 757GX

FT-757 GX Gen. Cvg. Xcvr.	$995.00	Call $
FT-767 4 Band New	1895.00	Call $
FT-211 RH	459.95	Call $
FT-290R All Mode Portable	579.95	Call $
FT-23 R/TT Mini HT	299.95	Call $
FT-209RH RM Handheld 5w	359.95	Call $
FT-726R All Mode Xcvr.	1095.95	Call $
FT-727R 2M/70CM HT	479.95	Call $
FT2700RH 2M/70CM 25w	599.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

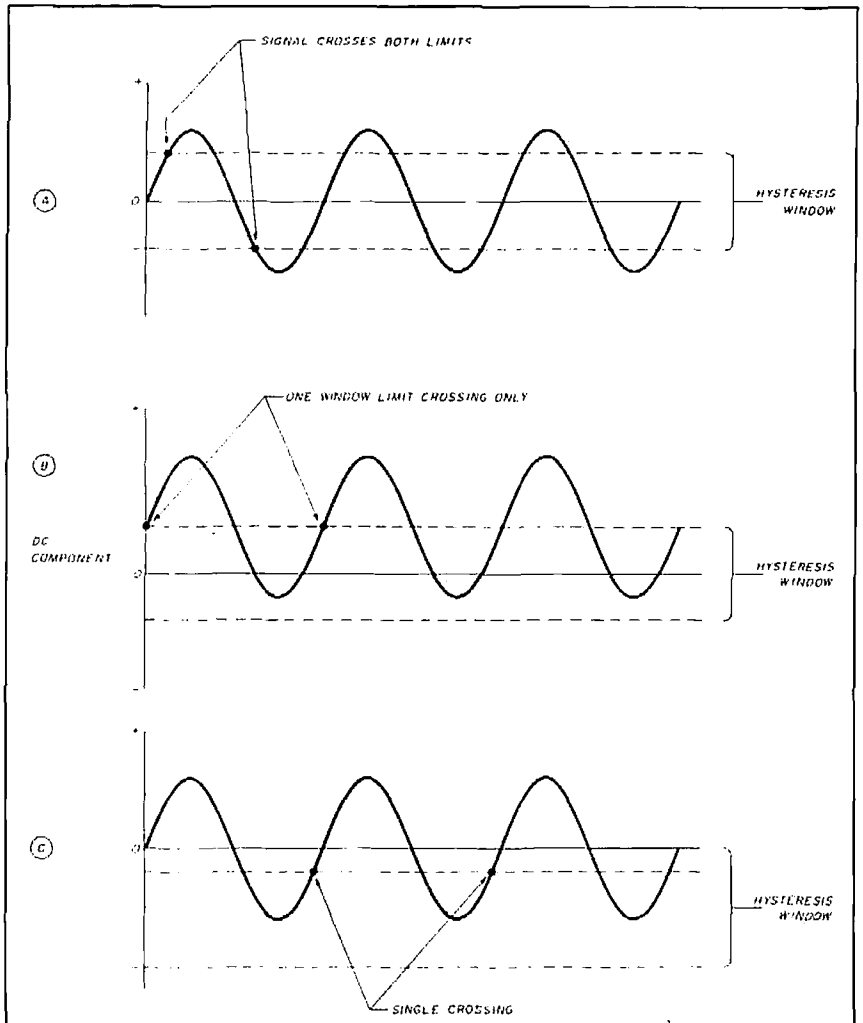


fig. 3. Several adjustments of trigger control: (A) Proper triggering occurs because signal brackets limits. (B) DC-offset prevents proper crossing of limits, so no count occurs. This situation occurs often in counters with a preset trigger window. (C) Signal only crosses one limit because trigger control is misadjusted.

Some instruments have a trigger level control allowing the user to adjust the window's position over a continuous range. Some models have a trigger switch that allows selection of three alternatives: Preset (usually centered about 0 baseline), ± (window above 0 baseline), and ± (window below 0 baseline). A trigger amplitude control makes it possible to change the window's width (i.e., the value of $(V_U - V_L)$ in fig. 2.

counter errors

Though several types of errors occur during digital frequency counter operation, they tend to fall into two general categories: inherent and signal related errors. Inherent errors are a function of the quality, age, history, and built-in design factors of the individual counter. Little can be done about them if the counter is poorly designed unless you are willing to spend some money. On the other hand, signal related errors are often correctable, or at least ignorable, through the proper manipulation of input sensitivity, trigger level, and amplitude controls.

Two major sources of inherent error in all frequency counters are: timebase error and one-count ambiguity.

The timebase error is expressed in terms of a percentage, or in parts per million. The error from the timebase inaccuracies is directly reflected in all measurements of frequency and period. For example, suppose a 1.00-MHz timebase is off by 30 Hz and is 1,000,030 Hz instead of 1,000,000 Hz. This is an error of 30 parts per million (30 ppm), which in percent is

$$\frac{(1{,}000{,}030 \quad 1{,}000{,}000)\ (100\%)}{1{,}000{,}000}$$

$$= 0.003\%$$

The measurement error due to timebase inaccuracy is constant regardless of the frequency being measured. That is, there will be a 0.003 percent error at 1 kHz or 10 MHz. For example, a 21.390-MHz (15 meter) signal would be measured with an error of

$$21.390\ MHz \quad \frac{30\ Hz}{MHz} \quad = 641.7\ Hz$$

This means that a counter reading 21,390,000 would indicate an actual frequency between (21,390,000 − 641.7) = 21,389,358.3 Hz and (21,390,000 + 641.7) = 21,390,641.7 Hz. If the timebase frequency is 30 Hz high, the reading will be low, and if the timebase frequency is 30 Hz low, the reading will be high.

Total timebase inaccuracy is the calibration error that occurs when the timebase is initially adjusted at the factory (or last properly re-calibrated), plus or minus factors like short and long term, temperature, and line voltage stability.

The initial error is directly related to the quality of the laboratory standard used at the factory or metrology laboratory. Proper standards, depending upon the quality of the counter, might be a WWV or WWVH broadcast (not high quality), a 60-kHz WWVB broadcast, or a cesium or rubidium beam standard traceable to the National Bureau of Standards (NBS).

The *short term stability* is the timebase oscillator frequency drift per day, while *long term stability* is the drift rate per month (sometimes called the aging rate). The *temperature change* is the timebase frequency change over a temperature range, usually specified as 0 to 50 degrees C for commercial and Amateur grade counters. The *line voltage change* is the frequency change over a ± 10 percent change in applied line voltage.

Temperature variation can be corrected by using an oven controlled crystal oscillator, or a temperature compensated crystal oscillator (TCXO). The latter is popular and practical for the majority of Amateurs. These changes are probably the most common modifications to improve the operation of low-cost counters. The problem of line voltage change is solved by making certain that the line voltage is regulated. It should be noted that some battery operated counters do exhibit this difficulty. The solution is to use a three-teminal IC voltage regulator to set the power supply voltage for the counter, instead of the internal battery pack.

There are four general classes of timebase used in counters: ac line, room temperature crystal oscillator, temperature controlled crystal oscillator, and oven controlled crystal oscillator. The first of these is found in only the least expensive counters, and incorporates the 60-Hz (50 Hz overseas) ac line frequency as the timebase. The problem is that the "60 Hz" is only marginally accurate over the short term. Although the power company maintains that its frequency is very accurate, that claim is valid only when integrated over a 24-hour period. The 60-Hz referenced counters are useless for measuring transmitter frequencies. The room temperature crystal oscillator is used on many, perhaps most, counters that Amateurs buy and offers only marginal accuracy and stability. The TCXO and oven controlled are best suited for accurate measurements. Although the oven was once the favorite, the TCXO type performs well and is inexpensive.

The *one-count ambiguity* is caused by a lack of synchronization between the input signal and the timebase. In some readings, a single cycle of the input signal may "escape" detection by the decimal counting assembly, so the reading is off by one count in the least significant position. The ± 1 count ambiguity produces an error inversely proportional to the frequency being measured and the gate time:

$$Error\ (\%) = \frac{+/-\ 100\%}{f\ T}$$

Where:
f is the measured frequency in Hertz (Hz)
T is the timebase "gate time", in seconds
EXAMPLE: Find the percentage error due to ±1 count ambiguity of a 2-MHz signal using a gate time of 1 second.
Error (%) = (±100%)/fT
Error (%) = (± 100%)/(2,000,000 Hz) (sec)
Error (%) = 0.0005 percent

The error is ± 1 count no matter what frequency is being measured, so the error decreases for higher frequencies.

The ± 1 count error should not be confused with last digit bobble, seen on some counters, even though the two are related. In this form of error, the least significant digit bounces back and forth between two values because it can't decide which value is correct. This error is seen on most counters, but is especially noticed on counters displaying only the most significant several digits. For example, my counter has a six-digit display, but measures frequency to 600 MHz. If a frequency is 21.390 MHz the reading might be "21390.0." But suppose the actual frequency is 21.389502 MHz? In this case, there is an ambiguity that may translate as a bobble between 21390 and 21389.

Signal related errors are problems (mostly in triggering) caused by poor quality or complex waveform signals. For example, don't even try to measure the frequency of an amplitude modulated or SSBSC signal! Most of these errors result from hysteresis crossing problems, or noise on the signal. Trigger errors occur because the input signal crosses the hysteresis win-

GORDON WEST'S
RADIO SCHOOL

21 DAY NOVICE



2 code tapes
112 page book
World maps
Frequency charts
Course certificate
Free magazine coupon
50 piece literature set!

$70 in equipment certificates from ICOM, KENWOOD, and YAESU **$19.95**

COMPLETE NOVICE COURSE **$49.95**
4 code tapes, 2 theory tapes, 2 text books, code oscillator set, examiner test pocket, and $70 discount coupons.

NOVICE TEXTBOOK **$4.95**
Written by Gordon West, this 112 page book contains all Novice questions and answers.

NOVICE CODE COURSE **$39.95**
6 tape stereo code course for learning the code from scratch. Includes certificates.

TECHNICIAN THEORY COURSE **$19.95**
2 theory tapes & 2 textbooks.

GENERAL THEORY COURSE **$19.95**
2 theory tapes & 2 textbooks.

TECHNICIAN/GENERAL COURSE **$19.95**
Combined tech & general course with 4 tapes and 1 book.

THE COMPLETE GENERAL **$49.95**
4 tapes & 2 books for theory plus 6 tape stereo code set for CW speed building.

GENERAL CODE COURSE **$39.95**
6 tape stereo code course for CW speed building from 5 wpm to 13 wpm.

THE COMPLETE ADVANCED **$49.95**
4 tapes & 2 books for theory plus 6 tape stereo general or extra class code course. (Specify which CW tapes you want.)

ADVANCED THEORY CLASS **$19.95**
4 tape stereo theory course plus fully illustrated theory book.

THE COMPLETE EXTRA **$49.95**
4 tapes & 2 books for theory plus 6 tape stereo code set for CW speed building 13 wpm to 22 wpm+!

EXTRA CODE COURSE **$39.95**
6 tape stereo code course for CW speed building from 13 wpm to 22 wpm+.

EXTRA THEORY CLASS **$19.95**
4 tape stereo theory plus fully illustrated theory book.

GORDON WEST ELECTRONICS BOOK
200 page marine electronics book plus marine mobile antenna hints. **$19.95**

COMMERCIAL TEST PREP BOOK **$29.95**
BRASS CODE KEY & OSCILLATOR **$19.95**
PLASTIC CODE KEY & OSCILLATOR **$14.95**
COPPER GROUND FOIL **60¢ FOOT**

SINGLE CODE TAPES
$9.95 EACH • BUY 2, GET 3rd ONE FREE

• 5 wpm Novice Tests • 5 wpm Random Code
• 5-7 Speed Build • 7-10 Speed Build • 10 Hump Jump
• 10-12 Speed Build • 12-15 Calls & Numbers
• 13 Random • 13 Test Prep • 5-15 General Quiz
• 13 Car Code • 13-15 Speed Build • 15-17 Speed Build
• 17-19 Speed Build • 20 Random • 20 Test Prep
• 20 Car Code • 10-24 Extra Quiz

Pass any upgrade & receive $25 Kenwood rebate
** plus a license holder & wall certificate FREE! **

Slow code uses 13 wpm character speed. Same day service. Add $3.00 UPS for courses, or $1.00 for single tapes. 100% return policy

GORDON WEST RADIO SCHOOL
2414 COLLEGE DR., COSTA MESA, CA 92626
Mon.-Fri. 10-4pm (714) 549-5000

153

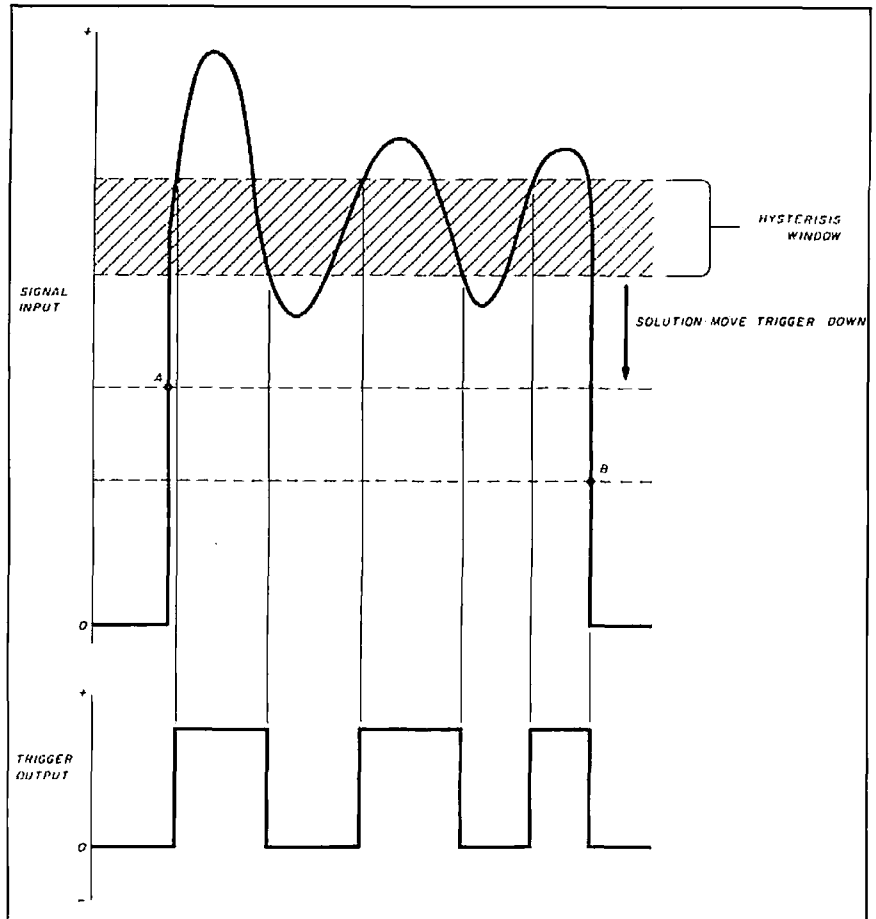


fig. 4. "Ringing" on pulse causes excessive number of trigger output counts when hysteresis window is positioned in shaded area, but correctly counts when window brackets "A" and "B".

dow limits either too many (excess counting) or too few (non-counting) times. Recall that the signal must cross the hysteresis limits in both directions on every cycle.

Figure 4 shows a signal with ringing that tends to amplitude modulate the pulse. If the hysteresis window on the counter is adjusted to the point shown shaded, then the amplitude variations caused by the ringing crosses the limits three times, so the count is of three pulses rather than one. To solve this, adjust the trigger control lower on the pulse so the triggering limits are "A" and "B" as shown.

Figure 5 shows a sine wave signal with severe harmonic distortion. If the trigger window is adjusted to point "B" then triggering occurs normally,

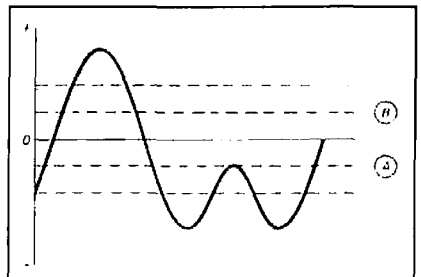


fig. 5. On distorted sinewave improper triggering occurs at "A" but not at "B". Trigger control should be adjusted to "B".

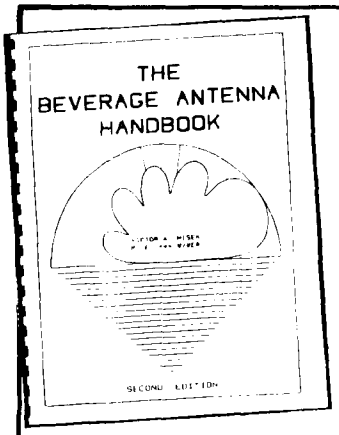
and there is no problem. But, if the trigger window is at "A" the counter will double trigger, producing an erroneous count.

In some cases, the sensitivity of the

counter input amplifier is simply too great. In those cases strong signals will drive the input amplifier into distortion and produce some of the problems discussed here. That is why it's a good idea to use a counter with an input sensitivity control, or conversely, an external attenuator if the counter is too sensitive. I plan to present a series of attenuators and pads useful for rf measurements and other applications in a future column.

The material presented here is based in part on *Elements of Electronic Instrumentation & Measurement* by Joe Carr, K4IPV, published by Prentice-Hall/Reston at $23.95. Although out of print, a limited number of hardback copies are available from the author at $15.00 postpaid. Contact J. Carr, POB 1099, Falls Church, Virginia 22041.

ham radio



new

FULLY REVISED
Second Edition

BEVERAGE ANTENNA HANDBOOK

by Vic Misek, W1WCR

Recognized around the world as the definitive work on Beverage Antennas. W1WCR has spent countless hours developing new antenna ideas and optimizing the SWA (Steerable wave antenna.) Misek delves deep into the secrets of the single wire Beverage with helpful hints and tips on how to maximize performance based upon wire size, height above ground, overall length and impedance matching. Also includes information on center fed Beverages constructed out of several wire types. ***CITY LOT OWNERS*** Note: Misek has developed a Beverage for you too! Called the Micro-SWA, it is just 60 ft long. You get excellent directivity and null steering capabilities. Transformer design information for both termination and feedline matching is completely revised. © 1987 80 pages 2nd Edition

☐**VM-BAH** **Softbound $14.95**

Please enclose $3.50 for shipping and handling

ham radio BOOKSTORE GREENVILLE, NH 03048 *603-878-1441*

ALL BAND TRAP "SLOPER" ANTENNAS!



FULL COVERAGE! ALL BANDS! AUTOMATIC SELECTION with PROVEN Weatherproof sealed Traps - 18 Ga Copperweld Wire! GROUND MOUNT SLOPERS - No Radials needed! Ground to rod or house waterfaucet! Connect Top to Trees, Buildings, Poles, etc at ANY angle from Straightup to 60 degrees for excellent "SLOPER" DX. Antenna Gain or bend it anywhere you need to! 2000 Watt PEP Input, max. Permanent or portable Use Installs in 10 minutes. SMALL - NEAT - ALMOST INVISABLE - No one will know you have a Hi-Power DX Antenna. Ideal For COND'Os APARTMENTS- RESTRICTED AREAS - Pre-tuned for 2-1 or less SWR over ALL bands (except 80-160-300kc) No adjustments needed - EVER. COMPLETELY ASSEMBLED, with 50 ft RG-8BU Coax feedline and PL259 connector - Built in lighting arrestor - ready to hookup! FULL INSTRUCTIONS!

No. 1080S - 80-40-20-15-10 — 1 trap 49 ft. — $59.95
No. 1040S — 40-20-15-10 — 1 trap 26 ft. — $58.95
No. 1020S — 20-15-10 — 1 trap 13 ft. — $57.95
No. 1015S-160-80-40-20-15-10 -2 traps 83 ft. - $89.95

SEND FULL PRICE FOR PP DEL IN USA (Canada $5.00 extra for postage etc) or order using VISA, MASCARD - AMER EXP. Give Number Ex Date. Ph 1-308-236-6333 weekdays. We ship in 2-3 days (Per Cks 14 days) Guaranteed 1 yr - 10 day money back trial.

WESTERN ELECTRONICS
Dept. AH Kearney, Nebraska 68847

✓ 151

AMATEUR RADIO MAIL LISTS
Self-stick 1x3 labels

*** NEWLY LICENCED HAMS ***
*** ALL NEW UPGRADES ***
*** UPDATED EACH WEEK ***

Total List = 462,728 (ZIP sorted)
Price is 2.5 cents each (4-up Cheshire)

BUCKMASTER PUBLISHING
Mineral, Virginia 23117
703:894-5777

✓ 152

NEMAL ELECTRONICS



- **Complete Cable Assembly facilities MIL-STD-45208**
- **Commercial Accounts welcome- Quantity pricing • Same day shipping most orders**
- **Factory authorized distributor for Alpha, Amphenol, Belden, Kings, Times Fiber**

Call NEMAL for computer cable, CATV cable, Flat cable, semi-rigid cable, telephone cable, crimping tools, D-sub connectors, heat shrink, cable ties, high voltage connectors.

HARDLINE 50 OHM

FXA12 1/2" Aluminum Black Jacket	*.89/ft*
FLC12 1/2" Cablewave corr. copper blk jkt	*1.59/ft*
FLC78 7/8" Cablewave corr.copper blk jkt	*3.92/ft*
NM12CC N conn 1/2" corr copper m/l	*23.00*
NM78CC N conn 7/8" corr copper m/l	*54.00*

COAXIAL CABLES *(per ft)*

1180 BELDEN 9913 very low loss	
1102 RG8/U 95% shield low loss foam 11ga	*C*
1110 RG8X 95% shield (mini 8)	
1130 RG213/U 95% shield mil spec NCV jkt	*A*
1140 RG214/U dbl silver shld mil spec	
1705 RG142B/U dbl silver shld, teflon ins	*L*
1310 RG217/U 50 ohm 5000 watt dbl shld	*L*
1450 RG174/U 50 ohm .100" od mil spec	

ROTOR CABLE-8 CONDUCTOR

8C1822 2-18ga and 8-22ga	*CALL*
8C1620 2-18ga and 6-20ga	

CONNECTORS-MADE IN USA

NE720 Type N plug for Belden 9913	*$3.95*
NE723 Type N jack for Belden 9913	*4.95*
PL259 standard UHF plug for RG8,213	*.85*
PL259AM Amphenol PL259	*.89*
PL259TS PL259 teflon ins/silver plated	*1.59*
PL258AM Amphenol female-female (barrel)	*1.45*
UG175/UG176 reducer for RG58/59 (specify)	*.22*
UG21DS N plug for RG8,213,214 Silver	*3.35*
UG83B N jack to PL259 adapter, teflon	*6.50*
UG146A SO239 to N plug adapter, teflon	*6.50*
UG255 SO239 to BNC plug adapter, Amphenol	*3.29*
SO239AM UHF chassis mt receptacle,Amphenol	*.89*

GROUND STRAP-GROUND WIRE

GS38 3/8" tinned copper braid	*C*
GS12 1/2" tinned copper braid	*A*
GS200 1-1/2" heavy tinned copper braid	*L*
HW06 6ga insulated stranded wire	*L*
AW14 14ga stranded Antenna wire CCS	

Shipping: Cable $3/100, Connectors $3.00, Visa/Mastercard $30 min, COD add $2.00
Call or write for complete price list Nemal's new 36 page CABLE AND CONNECTOR SELECTION GUIDE is available at no charge with orders of $50 or more, or at a cost of $4 with credit against next qualifying order.

NEMAL ELECTRONICS, INC. 12240 NE 14th Ave. N. Miami, FL 33161
(305) 893-3924 Telex 6975377 24hr FAX (305)895-8178

✓ 150

a diagnostic serial data latch

Convenient method of characterizing bit streams

I needed a convenient way to diagnose unsuccessful communication between two serially linked devices — a computer and printer, for instance. The serial data latch (SDL) I built monitors bit-stream or byte-oriented communication like RS-232.

Before developing the SDL, I used an oscilloscope and forced repetitive transmission of some character by one of the devices to confirm the number of data bits, stop bits, and parity. Watching the voltage levels on the oscilloscope trace to do this was inconvenient. The serial data latch catches one-time character transmissions and makes monitoring the dynamic transmission characteristics of the communication link easier. Combined with a break-out box to watch the more static "handshaking" lines, it is possible to have a complete system for determining the character of serial communication.

Most serial communication between personal computers conforms to the RS-232C standard. The SDL operation is described in terms of monitoring these signals. *Any bit stream link may be characterized* by modifying output interpretation.

You'll need knowledge of RS-232 communication to understand the descriptions in this article. Two devices are used for RS-232 data transfer: Data Terminal Equipment (DTE) and Data Communication Equipment (DCE). The names DTE and DCE originated when terminals began to be linked via communication equipment (modems) to large host computers. In the field of personal computers, such a distinction may be superfluous and distracting[1], but it is present.

Both DCEs and DTEs use DB-25 connectors 25 pin connectors with 12 pins on one row and 13 on the next, numbered from 1 to 25. Theoretically, a DCE should always use a female connector while the DTE uses the male plug[2].

Pins 4-6, 8, and 20 are used as data flow control signals. Articles have been written on how to correctly use these pins, but nonstandard methods abound in personal computer systems[3]. The original standard was designed for 110-baud (bit/second) terminals and modems. With higher speed communications now commonplace, a cleaner method of data flow control (at least in terms of how many wires link the devices) is to embed data flow requests in the data instead of adding hardware. The XON/XOFF protocol is one method used by personal computer programmers.

With this protocol you need to connect only three signal wires (see **table 1**). To tell if a device is acting as a DTE or DCE, use a voltmeter to measure the voltage on pins 2 and 3, using pin 7 as the reference. One should provide a significant reading; the other will be somewhere near 0 volts. The pin transmitting the data provides the voltage reading. This works whenever the device is on — not just when it is ready to send or receive data.

All data is carried on pins 2 and 3; the DTE transmits on pin 2 and the DCE on pin 3. The functions of the wires connecting the two are named with respect to the DTE: pin 2 is called *transmit data* (TxD) and pin 3 *receive data* (RxD), even though *each* transmits data from its associated device.

By Brian J. Mork, KA9SNF, 215 Paddock Drive East, Savoy, Illinois 61874

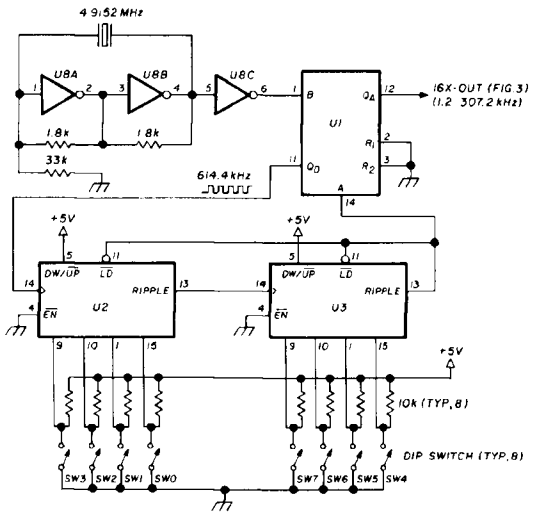


fig. 1. Baud rate generator schematic.

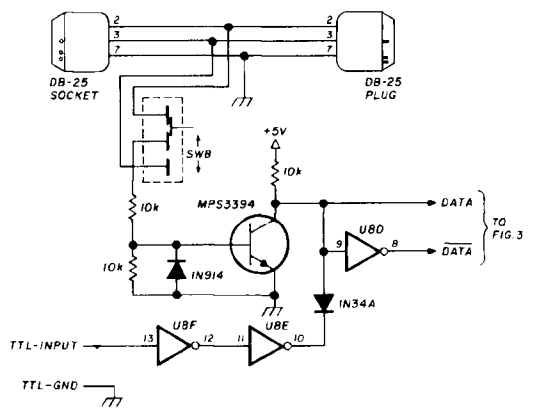


fig. 2. Input signal conditioning portion of the serial data latch.

Table 1. RS-232 standard dictates that a zero data bit ("space") be indicated by a voltage of 3 to 25 volts. A one data bit ("mark") is indicated by a voltage of −3 to −25 volts (voltages are to be measured into an open circuit load). Typically ±12 volts is used. The quiescent state of a data line (no data being sent) is marking.

pin 2: Voltage controlled by DTE and monitored by DCE ("TxD")

pin 3: Voltage controlled by DCE and monitored by DTE ("RxD")

pin 7: reference for above two voltages

To transmit, by definition, is to control the voltage on a wire. To receive data, the voltage is monitored. All voltages are relative to pin 7 — the logical circuit ground at both the DCE and DTE. Pin 1 of the DB-25 connector, the frame or chassis ground, should be connected to the inside of the metal cabinet of the computer or peripheral. Many times only three wires are used; the pin 1 connection is neglected. If each device is designed properly and powered with a grounded three-prong AC plug, the level of communication link integrity and personal safety should be acceptable.

Data is transmitted on pins 2 and 3 in a bit serial format (one bit at a time). If ten bits need to be transferred, they are sent one after another at specific intervals in a predetermined order. Each bit of data is asserted for the *bit time* which is equal to the reciprocal of the bit/second (baud) rate. The SDL records the voltage level on pin 2 or 3 (your choice) relative to pin 7 at different times. The voltage level at these times reflects the zero/one status of the bits of the data being sent and the start and stop bits. The "different times" are defined by a baud rate generator (BRG) which, in this context, is a variable speed clock generating a frequency at 16 times the baud rate.

circuit description

Figure 1 shows a baud rate generator circuit capable of creating a 16x-out signal in the 1.2-to-307.2 kHz range for communication rates of 75 to 19,200 bits per second.

The 4.9152-MHz crystal combined with three inverting gates of U8 provide a TTL (transistor-transistor logic) compatible clock. Counters B, C, and D of U1 divide the signal by 8 and provide a 614.4-kHz symmetric clock at pin 11 of U1.

U2 and U3 are configured as down counters that decrement on the rising edge of the 614.4-kHz signal. At some point, the rising clock edge will cause them to decrement to 0. As a result of the subsequent falling edge, pin 13 of U3 goes low causing the counters to reload with a value set by the DIP (dual in-line package) switches SW0-SW7. As soon as the counters load, pin 13 output rises (the count is no longer zero), causing counter A of U1 to toggle the Q_A output on pin 12. By changing the DIP settings, a variable frequency symmetrical square wave is available as 16x-out.

The DIP switches can be interpreted as a programmable divisor. Take, for example, a divisor of 1. This is the smallest divisor possible, and provides the fastest 16x-out frequency. On U2 and U3, a divisor of 0 (all DIP switches closed) gives the same results as a divisor of 1, but this mode of operation is not recommended. Dividing the 614.4-kHz signal by 1 provides a 614.4-kHz signal to counter A of U1, which divides

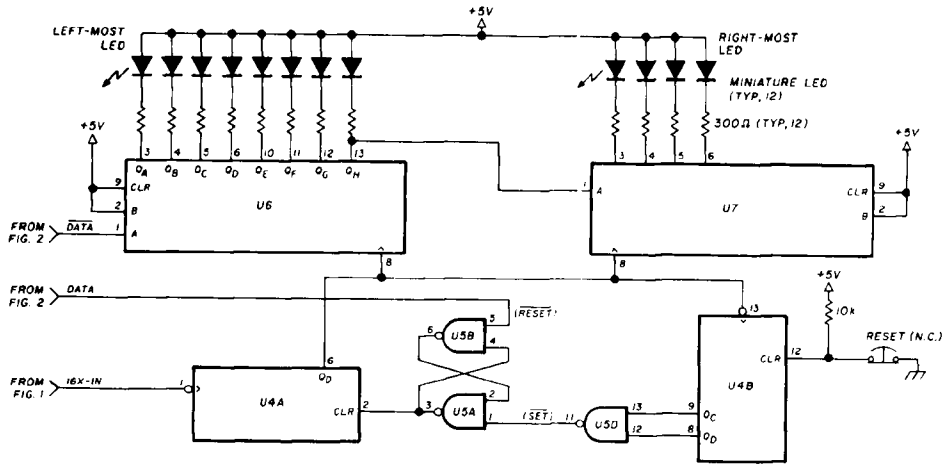


fig. 3. Clocking and display logic schematic.

the frequency by 2 to provide a symmetric 307.2 kHz-signal as 16x-out. This is 16 times the fastest baud rate commonly used with personal computers: 19,200 baud. Divisors for other baud rates can be found in **table 2**. For nonstandard baud rates, use the formula:

$$DIVISOR = \frac{19200}{baud\ rate}$$

Round the divisor to an integer, convert it to binary notation[4] and set it on the eight DIP switches. SW0 is the least significant bit (LSB) and SW7 the most significant bit (MSB).

Single chip programmable clocks are available and might replace the 3-1/2 chip baud rate generator described above. I designed the BRG using ICs I know are commonly available.

The input section shown in **fig. 2** conditions the TTL or RS-232 data from one of three data sources and provides normal and inverted data outputs.

The transistor buffers the nominally ±12 volt data lines, inverts the polarity and converts the signals to TTL compatible voltage levels. If nothing is connected to the DB-25 connectors, the transistor outputs marking status. The schematic calls for an MPS3394, but most NPN signal transistors will work.

The optional TTL input is twice inverted and wire-ORed with the transistor output. The double inversion attempts to preserve most of the noise immunity of the TTL gates by providing a locally (inside the SDL box) generated clean signal. Special noise considerations are needed because of the known voltage drop of the diode between U8e and U8d. Almost any germanium signal diode can be used in this application. The schematic calls for a 1N34A.

Using a transistor and a diode OR gate sacrifices simplicity as compared to RS-232 receiver/voltage converters like the Motorola 1489 and a TTL OR gate. But, the circuit as shown can accept both TTL and RS-232 signals with "automatic selection" — plug in the one you want to use.

The remaining circuitry (**fig. 3**) provides clocking logic and latches the data to be displayed on the LEDs. U5a and U5b act as a flip-flop. When the input data goes low (a start bit), the flip-flop output is reset low, releasing U4a to count pulses from 16x-in. U4a is configured as a divide-by-16 counter providing a symmetric Q_D output equal to the baud rate.

Halfway through the bit time (eight oscillations of the 16x-in), Q_D goes high, causing U6 and U7 to shift in new data. After the full bit time, Q_D goes low and U4b increments by one. Halfway into the next bit time, Q_D goes high again and shifts in the next data bit. This shift-and-count continues until U4b reaches 12 (both Q_C and Q_D outputs go high). U5d causes the flip-flop to go high, holding U4a in a cleared state. The data line may continue to change, but no more data is shifted into the LED shift registers. Opening the reset switch clears U4b, allowing the next start bit to cause 12 more bits to be latched.

The latched, inverted data is displayed on the LEDs by using the parallel outputs of the shift registers. If the data bit was a 1 (inverted data was low TTL) the corresponding LED will light. I call for 300-ohm current limiting resistors in the schematics, but used 390-ohm resistors because they were available. You can get a brighter display by lowering the resistor values to a minimum of about 100 ohms.

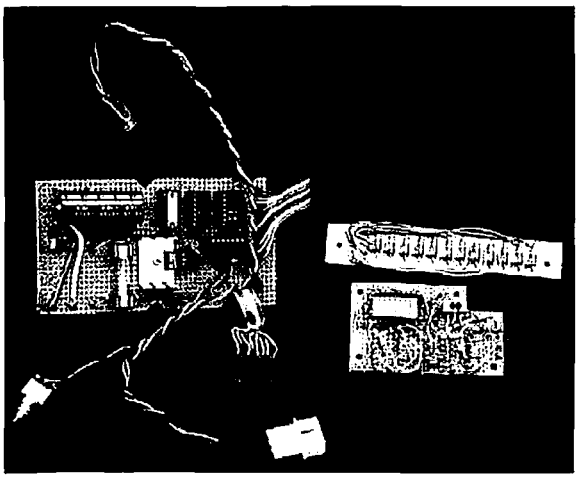
The power is supplied by a 1/2 ampere (minimum) 5-volt supply. I used a three terminal fixed-voltage regulator (7805) based circuit, but you can use any equivalent power supply. If you choose a 7805, mount it on a heat sink as it will be sourcing current near ca-

Table 2. DIP switch settings for common baud rates. See the text for calculation of settings for non-standard baud values.

Bits/second (baud rate)	DIP switch settings (76543210)
75	11111111 (1 = open)
110	10101111
300	01000000
1200	00010000
2400	00001000
4800	00000100
9600	00000010
19200	00000001

Table 3. Power connections, ground connections, and unused pins for all ICs.

	type	+5 volts	Ground	Not connected
U1	7493	5	10	4,6,7,8,9,13
U2	74191	16	8	2,3,6,7,12
U3	74191	16	8	2,3,6,7,12
U4	74393	14	7	3,4,5,10,11
U5	7400	14	7	8,9,10
U6	74164	14	7	- none -
U7	74164	14	7	10,11,12,13
U8	7404	14	7	- none -



My version of the SDL was built on three perfboards. The largest holds the power supply and clocking logic of *fig. 3*. The long thin LED display board, the BRG (with the block of dip switches), and all "'external" connections branch off this main board. The BRG board also supports the slide switch shown in *fig. 2*.

pacity and getting warm. There is more information available about the 7805 or alternate designs[5].

construction

Everybody has his way of constructing an electronic project. I won't tell you how I'd do it if I were you, but to aim beginners in the right direction, some general comments are in order.

I've had success with perfboard construction using a hybrid of solder and wire-wrapping. As you see in the construction photo, I made three separate boards linked by ribbon cables. Be generous with connectors.

First lay out large components like power supply parts and IC sockets; then solder power supply connections to all sockets and other durable components (capacitors, pull-up resistors, LEDs) that aren't easy to wire-wrap. Before installing additional components, check for proper application of power to this subassembly. Testing after the framework of the circuit is established prevents most damage. A voltmeter can be used since the voltages are not time dependent. Once the basic layout works, solder any "off-board" wiring (to the reset switch and DB-25 cable) to posts inserted in the perfboard. Finally, wire-wrap the rest of the connections and install the ICs.

Solder provides low resistance paths for the high current connections, with immunity to noise and TTL switching transients. If a mistake is made, it's easy to correct because the boards are uncrowded by signal wires. On the other hand, wire-wrapping allows for easy correction or modification of signal wires.

The power and ground connections, and the IC pins to be left unconnected, are given in **table 3**. All resistors should be 1/4 watt. Switch SW8 works best as a slide switch. The LED and DIP switch pull-up resistors take less room if put in single in-line packages. The RS-232 connections should use two DB-25s (one male, the other female). I made other external connections using a female miniature header. A two-piece aluminum box holds the circuitry but almost any enclosure is suitable. Other circuit details are found on the schematics.

operation[4,6]

The first half of this section describes how to set up the BRG/SDL for use; the second explains how to interpret the information. Normal setup of the SDL involves plugging it in, providing a clock signal, and connecting it to a data source or between two devices (it passes the data unaltered). Block diagrams of different ways to use the BRG/SDL are shown in **fig. 4**.

The data to be latched may come from one of three places: pin 2 or 3 of the DB-25, or the TTL input. RS-232 compatible voltage levels must be provided to either the male or the female connectors (see **table 1**) if pin 2 or 3 or the DB-25 is used as a data source. Either connector may be used as input and the other is then available as output. With switch SW8 you can monitor either the DTE or DCE transmissions (pin 2 or 3, respectively).

The TTL input won't normally be used, but does

allow direct connection to the TTL compatible serial outputs of universal asynchronous receiver-transmitters (UARTs) like the 8250 or 8251 (avoiding the hassle of converting to RS-232 signals if they aren't otherwise available). The TTL input is measured against the SDL common (pin 7 of the DB-25 or equivalently the TTL-gnd input). Quiescent TTL data line state is high or "marking" with the start pulses going to low or "spacing" status.

You should connect either an RS-232 *or* TTL source. If you connect both, the circuit will not be damaged, but the results on the LED display may not be as described below.

Connect the 16x-out and 16x-in to use the internal BRG (**figs. 4A, 4C**, and **4F**). To use an external clock, leave 16x-out disconnected and connect the clock to 16x-in. Be sure to provide a good voltage reference for the TTL-compatible clock input. If the clock is relative to the same logic ground as pins 2 and 3 (the two grounds are connected inside the peripheral or computer and are available on pin 7) and the DB-25 is connected, you only need one wire. You can often access the 16x clock by taking the cabinet cover off the data source (your computer or other device) and connecting 16X-in to an appropriate integrated circuit pin (pin 9 of an 8251 operating in the 16x mode[6] or pin 15 of an 8250, for example). This is shown in **fig. 4B**. If the clock ground and pin 7 ground aren't connected via the DB-25 connector, two wires must be carried from the clock source (**figs. 4D, 4E**, and **4G**). In this case, connect the clock reference to the TTL-gnd input (which in turn is still connected to pin 7 of the DB-25 connector inside the SDL). Although this project allows the versatility of external clock sources, the integral BRG is normally used.

You must set the eight-pin dip switch to use the internal BRG. Settings for common baud rates are shown in **table 2**. A formula for nonstandard baud rates is provided in the circuit description section of this article.

After setting up the clock and data sources, plug in the SDL. No switch is provided — the SDL is always on. The LEDs show random on-and-off status and data input will be ignored. Reset the SDL by pressing the reset button. As soon as the data line goes to spacing status, a start bit is occurring, and 12 consecutive bits will be latched to the display.

When accepting RS-232 data, the LED on the far right should always be off, corresponding to the start bit, which is sensed when the data line goes from marking to space status. If it is on, either the SDL is malfunctioning, the baud rate of the transmitter is too fast, or the BRG is set too slow. This happens because subsequent data bits arrive too rapidly and get latched as the start bit.

Moving from right to left, the next eight LEDs reflect the data sent (assuming 8 data bytes — otherwise the next seven LEDs for 7 bits of data, and so on). Since the LSB is always sent first by RS-232 standard, the bit next to the start bit is the LSB. By referring to an ASCII table, you can determine what data was sent by the computer.

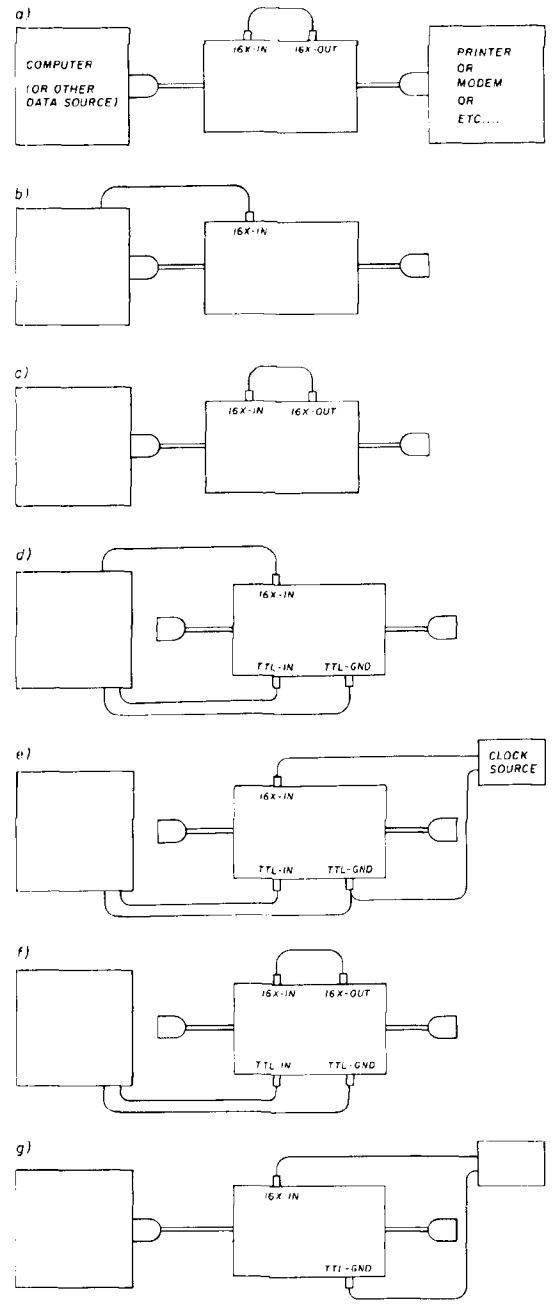


fig. 4. Illustration of several possible methods for using the SDL/BRG. Probably the most common setup is shown in A. See text for more complete setup instructions.

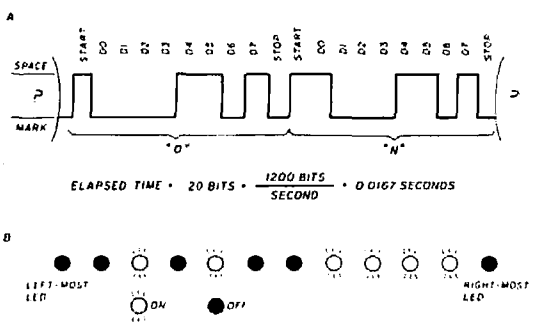


fig. 5. (A)Condition of an RS-232 data line sending the word ""ON" as fast as possible at 1200 baud with 8 data bits, no parity bit, and 1 stop bit. (B)Condition of the 12 SDL LEDs if the above data was received after reset.

An unknown transmission rate can be determined if it is a "standard" one (as listed in **table 2**). To do this, set the BRG for 19,200 baud. Reset the SDL and send a delete character (all data bits are mark status — opposite from the start bit) through the latch. The first data bit LED (the one just left of the start bit) may be on or off. If it is off, the device is transmitting slower than 19,200 baud. Move the DIP switches to the 9600 baud positions. Reset the SDL and send another delete character. Continue decreasing the baud rate until the first data bit LED goes on. This corresponds to the standard baud rate being used by the data source.

To the left of the data bit LEDs is the stop bit display. It will be on. The stop bits (there must always be one or more) serve two functions:

- a time delay to allow the UART to collect bits into a coherent byte and make it available to the peripheral controller,
- to force the data line to a status different than the next start bit.

If there were no stop bits and a character ended with the line in start bit status, you could not tell when the real start bit of the next character was sent. When the next character's start bit immediately follows the stop bit, the stream of characters is moving at its highest speed — see the diagram for sending the word "ON" (ASCII decimal values 79 and 78 or 01001111 and 01001110 in binary) in **fig. 5A**. The stop bit(s) follow the start bit at different times depending on how many data bits there are. A parity bit, if there were one, would appear between the data and the stop bit and shift the stop bit one more bit time later.

LEDs left of the stop bit are extras and normally match it (are on). If these LEDs are off, another start bit was latched. For example, if the SDL were reset and the word "ON" was sent as in **fig. 5A**, you would see the LED pattern shown in **fig. 5B**.

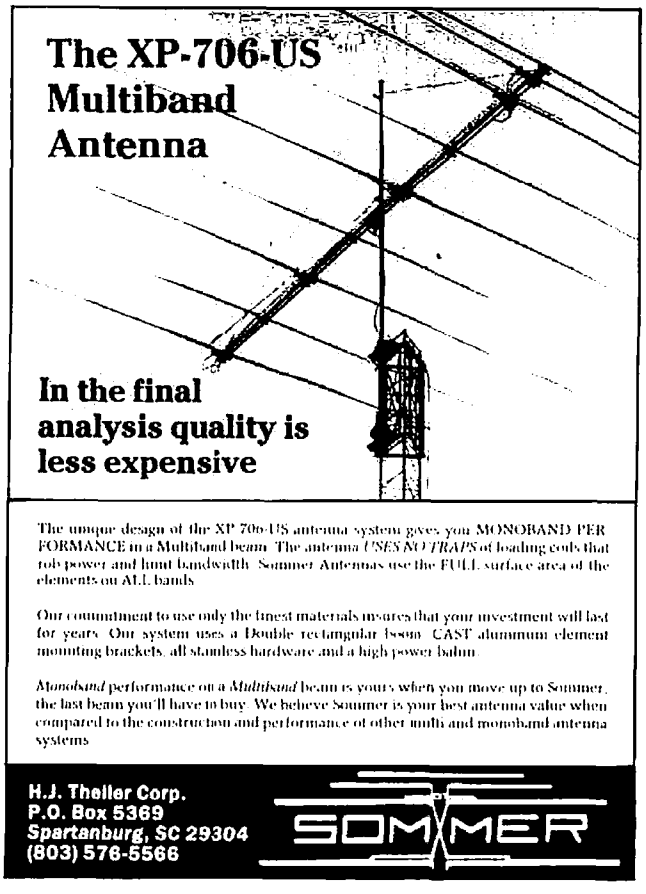
By sending different characters and monitoring the LEDs, you can use the SDL to determine a baud rate and confirm the presence of start, stop, and data bits. Verifying the operation of a communication link is often part of solving a larger problem, and this device allows you to confirm or rule out a problem in this area.

If you build an SDL using my design or your own I'd love to hear from you. If you have any questions, just write. Please include an SASE if you want a reply.

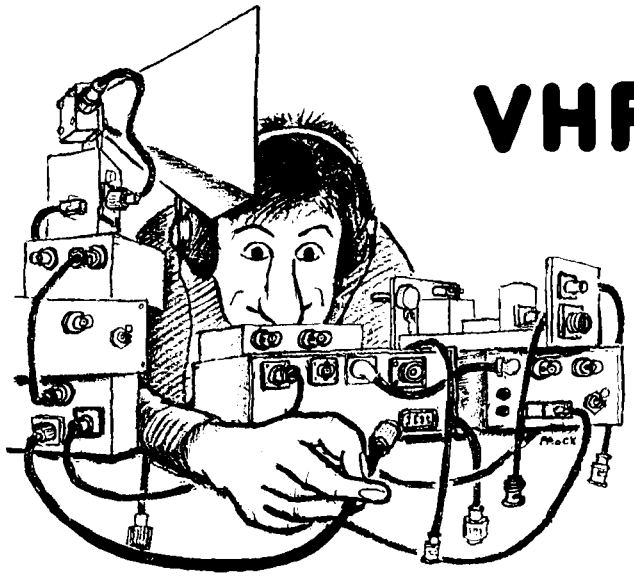
references

1. Pete Klammer, "Hermaphroditism Strikes," *Byte*, October 1985, pages 22-24.
2. Steve Liebson, "The Input-Output Primer, Part 4: BCD and Serial Interfaces," *Byte*, May 1982, pages 202-220.
3. L. Dennis Page, "RS type Communications Standards: Users Stick with Established Norms," *Personal Engineering and Instrumentation News*, April 1987, pages 35-44.
4. Paul Horowitz and Winfield Hill, "The Art of Electronics," Cambridge University Press, 1980, page 318. Illustrates method of converting a decimal number to a binary notation.
5. 78xx regulator data in *National Semiconductor's Linear Data Book; 1984 Radio Amateur's Handbook* Chapter 5; "Circuit Cellar," *Byte*, July 1985.
6. Intel 8251 data sheet, *Microsystem's Component Handbook, Volume II*. Pin 9 can be programmed to be accepted as 1x, 16x, or 64x the baud rate.

ham radio



161



VHF/UHF WORLD

Joe Reisert, W1JR

microwave components and terminology: part 2

Last month we talked about rapid changes in the state of the art (SOA) — some older microwave components are either becoming extinct or moving much higher in frequency. Because their names, usefulness, and modes of operation are often lost during times of transistion, the March and April columns are devoted to them.

In March our primary focus was microwave transmission lines and waveguides. This month we will discuss other microwave components and terminology.

couplers

There are many types of couplers used to monitor and couple energy into or out of a transmission line. The simplest are bidirectional and nothing more than voltage dividers using resistors, capacitors, or transformers as shown in **figs. 1A, 1B,** and **1C**, respectively. In each case the value of the component can be adjusted for the desired coupling factor.

Bidirectional couplers are convenient for reducing power and monitoring the signals on a transmission line with little or no insertion loss to the primary source. The main disadvantages are that the output level is often inaccurate and varies with component value choice and VSWR on the main line.

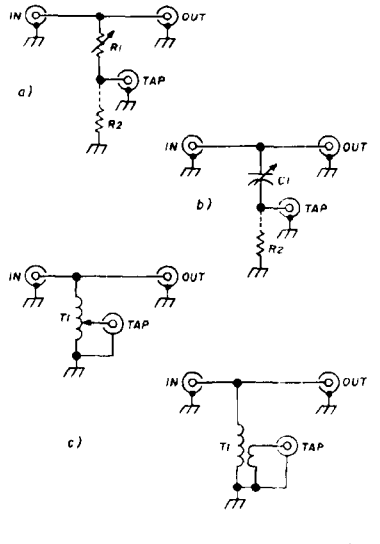


fig. 1. Simple bidirectional couplers (A) resistive divider. R_1 sets coupling factor; R_2 may be used to stabilize level, (B) capacitance divider. C_1 sets coupling; R_2 (if needed) may be used to stabilize level, (C) transformer divider. Either tapped or conventional transformers are usable.

Directional couplers, useful from hf through microwave, consist of two transmission lines loosely coupled together in such a way that a wave traveling in one direction in the main line excites a unidirectional wave in the other line. On the hf and VHF bands, hybrid couplers are fabricated with special transmission line transformers.

The difference in the rf level between the main line and the coupled port is called the coupling factor. It is usually specified in dBs, and easily controlled. Typical coupling factors are between 10 and 40 dB. The lower the coupling factor, the greater the power loss through the coupler. For instance, a 10-dB hybrid coupler would have an insertion loss of at least 0.45 dB and a 20-dB coupler only 0.05 dB.

In an ideal directional coupler, waves propagate in one direction as shown in **fig. 2A**. Isolation between the output and the uncoupled ports is referred to as "directivity" and expressed in dBs. High values of directivity imply better performance, with an "average" coupler exhibiting 20-25 dB directivity and a superior unit 30-40 dB.

At UHF and below, directional coup-

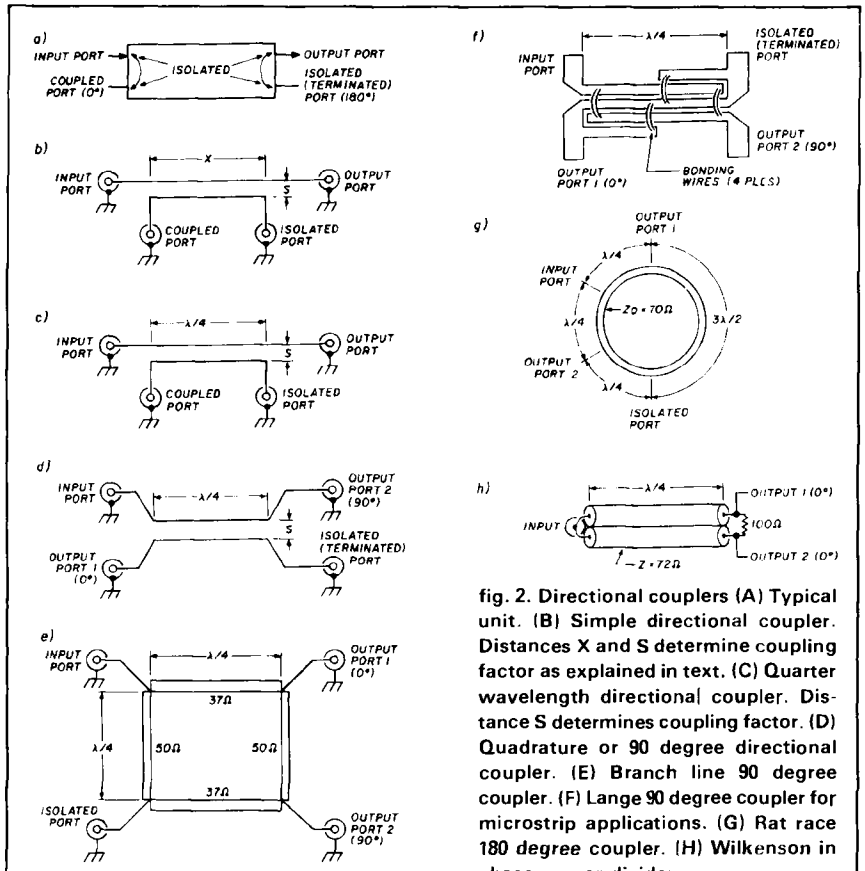


fig. 2. Directional couplers (A) Typical unit. (B) Simple directional coupler. Distances X and S determine coupling factor as explained in text. (C) Quarter wavelength directional coupler. Distance S determines coupling factor. (D) Quadrature or 90 degree directional coupler. (E) Branch line 90 degree coupler. (F) Lange 90 degree coupler for microstrip applications. (G) Rat race 180 degree coupler. (H) Wilkenson in phase power divider.

lers are often made up of coupling *loops or short wires* placed in the vicinity of a transmission line (see **fig. 2B**). Coupling is a function of the length (X) and spacing (S) of the probes to the main or inner conductor of the transmission line. Longer coupling lines (up to 0.25 wavelengths) and closer spacings (to the main transmission line, X) equates to higher coupling to and loss through the main line.

If the coupling line is very short, it takes the form of a magnetic (current) coupling. When it is long, typically 0.1-0.25 wavelength, it is an electric (voltage) coupling. The "monimatch" is a magnetic type of coupler which is usually more frequency sensitive and has only moderate directivity.[2,3]

The quarter wave (**fig. 2C**)[4] is the most common directional coupler used in the UHF and microwave region. It has a very constant output over approximately 30 percent bandwidth. Throughout this range the output and directivity of the coupled port are steady. Some construction examples are described in references 4 and 5.

Quarter-wave couplers can also operate at the third harmonic, so a 432-MHz coupler is probably useful at 1296 MHz. Commercial couplers are sometimes designed with multiple coupled sections in tandem, allowing them to work over extended frequency ranges. This kind of directional coupler usually has higher insertion loss and is considerably larger (in length) than narrower bandwidth types. Also note that many couplers are terminated internally and appear outwardly to be only three-terminal devices.

Couplers have many uses: one is to monitor power. **Figure 3A** shows a coupler used as a wattmeter monitoring the output of a transmitter. **Figure 3B** shows how a directional coupler can be used to monitor VSWR.[5]

The injection of local oscillator signals into a mixer is another microwave application for directional couplers (see **fig. 3C**). Couplers can also be used as output levelers for monitoring frequency, and on a system's input for signal or noise injection.

quadrature couplers

The quadrature, or 90 degree, is a special type of coupler often referred to as a 3-dB coupler. Its outputs are equal in amplitude, but 90 degrees out of phase (**fig. 2D**). When first introduced, quadrature couplers consisted of two very tightly coupled quarter-wavelength lines. In the simplest physical configuration, they were two very tightly coupled transmission lines (usually striplines) sandwiched together and separated by a thin dielectric.[6]

Other UHF and microwave equivalents like the Wireline™, branch-line, and Lange couplers are now popular since they are easier to build.[7,8,9,10] Sage Labs developed Wireline to provide a unique line section that can be conveniently cut to the proper length. It looks like a piece of shielded twin lead with the wires separated only by their enamel coating.

The branch-line coupler is shown in

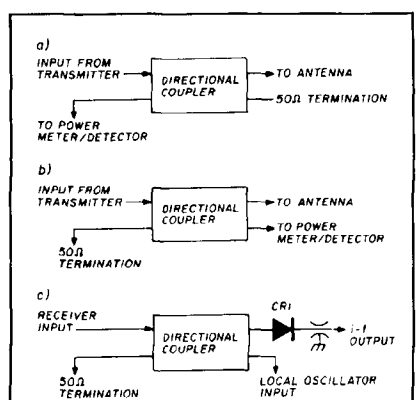


fig. 3. Coupler applications. (A) Transmitter power monitor. (B) A VSWR monitor. (C) Mixer application. CR_1 is a mixer diode. Directional coupler is typically 7-10 dB, hence the local oscillator power must be increased by a similar amount.

fig. 2E.[8] It is easy to construct, especially in microstrip. The Lange coupler, **fig. 2F**, was developed for applications where a small quadrature coupler was required in hybrid circuits.

Quadrature hybrids are popular for generating circular polarization and combining power amplifiers.[6,8] Other applications and examples are described in references 7 through 10.

hybrids

The hybrid coupler is usually a device with either in phase (0 degree) or out of phase (180 degree) outputs.[7] The "rat race" shown in **fig. 2G**[10] is a common microwave version often used in balanced mixers.

Another hybrid is the Wilkinson in-phase power divider that provides two in-phase outputs of equal power level in isolation from each other. It is used where dual outputs are required, as in local oscillators and transmitter power division and addition.[10]

circulators and isolators

Circulators and isolators may be among the most interesting microwave components. The basic configuration is called a circulator — a three or more port nonreciprocal device using microwave ferrite material and operating on the principle of Faraday rotation.

The basic coaxial microwave circulator has three 50-ohm ports illustrated in **fig. 4A**. RF entering port A travels in only one direction (clockwise as shown) to the adjacent port, B, with very low attenuation, typically 0.1-0.2 dB. If there is any mismatch to the device connected at port B, it will be reflected to port C. Any impedance mismatch at port C will cause a reflection back to port A and so forth, always traveling in the same direction.

Circulators are used to provide good impedance termination to a receiver or transmitter. To do this, the third or C port is terminated with a well-matched 50-ohm load (see **fig. 4B**). In this configuration it is referred to as an isolator. The (reverse) isolation of a typical isolator is approximately 20 to 30 dB.

Figure 4C shows a typical receiver application that uses an isolator. Here

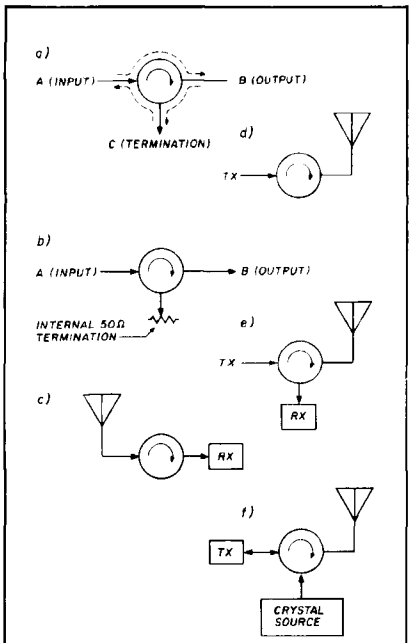


fig. 4. Circulators and isolator applications. (A) Typical circulator. (B) Typical isolator with internal termination. (C) Method to isolate receiver input from antenna using an isolator. (D) Method using isolator on output of a solidstate transmitter to lessen the possibilities of generating intermods see text. (E) Circulator used as a T/R switch. (F) Typical method of injection locking through a circulator as explained in text.

both the antenna and the receiver always see a good impedance match regardless of the actual device VSWR. **Figure 4D** shows how to use an isolator in a transmitter application. The advantage is that the antenna VSWR can degrade significantly without affecting transmitter operation.

The arrangement in **fig. 4D** has another very practical Amateur application. FM repeaters are often located where there are high levels of rf, especially when the antenna is co-located on a tower with other transmitting antennas. Any rf entering the output of a transmitter, especially one with a solid-state final, will cause nonlinearities in the output stage and may result in the generation of spurious outputs that look like other transmitted signals. Though a problem in the early days of fm repeaters, this has been significantly improved using ferrite isolators.

The use of a circulator in a TR (Transmitter/Receiver) configuration is shown in **fig. 4E**. If there is sufficient isolation between ports, mechanical T/R relays are not required. Even if relays are required, the circulator will increase the isolation and thus the protection of the receiver.

Figure 4F shows the stabilization of free-running transmitters using the principle of injection locking. A stable source (typically a crystal oscillator driving a multiplier) is coupled through a circulator, resulting in a stabilized transmitter.

microwave amplifiers and oscillators

Older types of microwave amplifiers and oscillators abound.[12] Many use vacuum tubes and were developed primarily as components of RADAR systems because the triodes, pentodes, and similar available tubes had long transit times. Newer tubes often used the transit time in achieving their normal operation. Earlier microwave vacuum tube types were the klystron, TWT (traveling wave tube), BWO (backward wave oscillator), and magnetron.

The Varian Brothers invented the klystron prior to World War II. The basic amplifier form has an input cavity resonator (called the buncher), a field-free drift space, an output cavity resonator (called the catcher), and a collector electrode.[12] It requires a rather elaborate biasing scheme with floating supplies.

Klystrons are primarily used above 500 MHz and can yield high linear power gain (20-40 dB) at very high rf power levels at 30 to 40 percent efficiency in CW, SSB, or pulse modes. High-power klystrons are used by some Amateurs for power amplification on 1296 and 2304 EME.

The reflex klystron is a single cavity klystron configuration with a repeller. Often used as a low-power 1 to 20 milliwatt oscillator, reflex klystrons were popular in the early microwave days as local oscillators, pumps, and transmit-

ters. The klystrode, a more modern version of the tube, is a single cavity klystron with lower gain but higher efficiency.

The TWT's invention was first announced in 1946, but the tube was not available commercially until 1949 when Varian Associates released an S-band (2-4 GHz) amplifier.[12,13] It differs from conventional tube amplifiers in many ways. First, the power supply positive terminal is grounded. All the control elements of the tube (filament, cathode, grid, anode, and helix) must be floated with respect to the collector, which is at ground potential. DC voltages are usually regulated and often in the 1 to 2,000 volt range. Gain is very high, 30 to 50 dB, and typically flat over an octave bandwidth (e.g., 2-4 GHz).

The TWT can be designed as either a moderately low noise figure (3-7 dB) amplifier or a linear power amplifier for transmitters with power outputs exceeding 100 watts up through 10 GHz. Many TWTs are being replaced (at least at lower power levels) by SOA solid-state amplifiers because of the complexity of the power supply, moderate size, and high cost. This is a boon to Amateurs who often find "obsolete" TWTs on the surplus market! These tubes have recently been used as transmitter output power amplifiers for Amateur EME records on 3.4 and 5.6 GHz.[14]

The BWO, sometimes called the Carcinotron, arrived in 1963.[12] An outgrowth of the TWT amplifier, it is inherently a low output power (1-10 milliwatts) oscillator. Its name, backward wave oscillator, reflects the fact that electrons travel in a direction opposite from that in which the wave is propagated.

BWOs can be used at extremely high (100 GHz) frequencies. They are not too prevalent in the Amateur market but were widely used as the tuneable local oscillator in the early spectrum analyzers.

Many Amateurs are probably familiar with the magnetron — the typical power source in the 2450-2500 MHz microwave ovens found in today's kitchens. Primarily an oscillator that can be used either in CW or pulse modes[15], it played an important part in the development of high-power levels for the early radars.

In the magnetron, the electron flow from the cathode to the plate is mainly influenced by a magnetic field applied perpendicular to the cathode-anode path and by the field effects produced by the anode cavities. It uses large magnets, high voltages, and is usually operated in the pulse mode. However, as discussed in reference 15, the type in consumer microwave ovens is not suitable for Amateur operations.

microwave solid-state amplifiers and oscillators

Solid-state devices, like vacuum tube microwave amplifiers, are widely used although they appeared later. Most applications use one of the many types of microwave diodes discussed in references 16 and 17.

The earliest solid-state microwave applications were mixers and detectors, first with germanium, and then silicon and gallium arsenide diodes. Development of the paramp (parametric amplifier), or negative resistance amplifier, followed using varactor diodes.[17] The late Sam Harris, W1FZJ, was influential in creating paramps for the Amateur.[18] Noise figures as low as 1.0 dB were reported for the first time making EME possible on 1296 MHz.

The paramp uses a pump or extra oscillator typically operating at five to ten times the amplifier frequency. Amateurs first used low-power reflex klystrons, and later Gunn diode oscillators (reference 17). Microwave circulators made paramps more stable by providing a good impedance match regardless of the load.

Microwave tunnel diodes (Esaki diodes) were also used as microwave detectors and oscillators. They were subsequently developed into negative resistance amplifiers, but the noise figures were only moderate and the dynamic range was poor. Most microwave amplifiers and oscillators now use silicon bipolar transistors, GaAs (Gallium Arsenide) FETs, and HEMTs.[19,20]

other microwave diode applications

Diodes can be used as multipliers. Common types are varactors and SRDs (step recovery diodes). Noise diodes can be used for testing the sensitivity or noise figure of amplifiers. Limiter diodes are common in the microwave region as protection for other solid-state devices. This is particularly important since mechanical relays have less isolation at higher frequencies.[17]

filters and filter elements

Discrete components like coils and capacitors are normally used on frequencies up through UHF, but as you go higher in frequency, capacitors often become inductive. Low values of inductance are also difficult or impossible to realize. For these reasons cavity-type filters became popular in the microwave region. **Figure 5A** shows a re-entrant cavity. The capacitor is often eliminated by adjusting the length of the inductor or center element.

Waveguide is often used as you go higher in frequency. Multiple section filters can be fabricated by placing partitions in a waveguide. Holes or cutouts are made to couple energy between sections; these openings are called irises. Screws or tuners are placed in the walls of the waveguide to tune the elements (reference 21).

Other filter elements are evolving. One is the YIG (yttrium iron garnet) sphere — a small resonant crystal structure that can be electronically tuned through the application of a magnetic field. The SAW (surface acoustic wave) resonator made from crystals is another being used for filters, replacing crystal resonators. It typically operates between 50 and 1000 MHz. Of more recent popularity are dielectric resonator materials used in DROs (dielectric resonator oscillators) or in tuners, as shown in **fig. 5C**.

microwave power measurement

It is frequently necessary to determine microwave power levels. At very low levels (less than 10 milliwatts) this is often done with detector diodes as described in reference 17. At higher

levels, a diode detector can be placed at a lower power level using a directional coupler as in **fig. 3A**.

Several other devices were developed to accurately measure microwave power up to the 100 milliwatt level. One, the bolometer (a resistor with a high temperature coefficient of resistivity), is usually mounted in a probe and connected to a bridge circuit which senses the rf power levels. Common bolometers are the thermistor, a resistance element made of a semiconducting material with a negative temperature coefficient; and the barretter, a metallic resistor with a positive temperature coefficient. They are used with detection circuitry that senses resistance change versus power level.

The calorimeter is another instrument used for microwave power measurement up through 10 watts. Usually a self-contained unit without an external probe, it detects heat through a self-balancing bridge that has identical temperature sensitive resistors in each leg.

microwave frequency measurement

Wavemeters were used to measure microwave frequencies before the advent of accurate meters. Two basic wavemeter types are the absorption and reflective. The absorption type usually has a resonant filter and built-in detector which could consist of a frequency calibrated re-entrant cavity (see **fig. 5A**) inserted in the test setup in **fig. 6A** and followed by a diode detector.

Reflective wavemeters are still used, especially at microwave frequencies. They are usually made up of a tuned circuit lightly coupled to a waveguide (**fig. 6B**). When tuned to the operating frequency, they extract a minute amount of power causing a slight power drop in the main line. Because of its appearance, this wavemeter has been nicknamed the "coffee grinder".

Lecher and slotted lines are two other kinds of microwave frequency measurement gear. Lecher lines are primarily reserved for the VHF and UHF frequencies where balanced lines are used.

The slotted line is practical in UHF and microwave regions and can be found at flea markets (see **fig. 6C**). It is made up of a detector and narrow slot cut in a coaxial line or waveguide. A detector probe is inserted a short distance into the slot (and hence the line) to extract a small amount of rf power. If there is a slight impedance mismatch on the line, the probe can be moved back and forth between the voltage peaks. The physical distance traveled can be measured and converted to frequency.

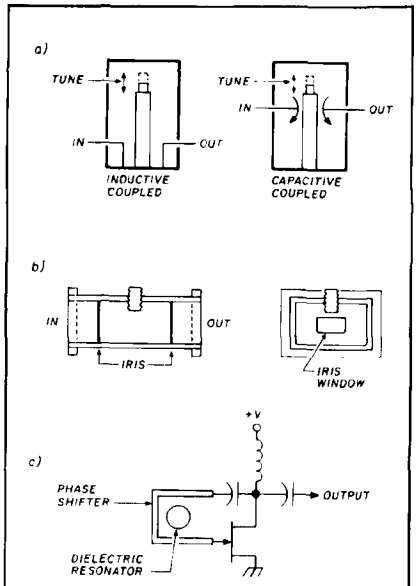


fig. 5. Typical filters and resonators. (A) Cavity quarter wavelength filter either inductive or capacitance coupled. (B) Waveguide filter using iris coupling. (C) FET oscillator using dielectric resonator to stabilize frequency.

impedance matching

Impedance matching is a big problem, especially at microwave frequencies. Old-timers will jokingly say that they used to tune a waveguide by denting it with a ballpeen hammer — believe it! Nowadays screws or dielectric strips are often placed in waveguides or near a transmission line. Many of these techniques are explained in reference 21.

Discontinuities, imperfections, impedance changes, connectors, and fringing effects are particularly troublesome on the microwave frequencies because the wavelength is so short. As a result, greater attention must be paid to minor details, especially rf connectors.[22,23]

An older type of waveguide impedance matching used a sliding short — basically a piece of waveguide shunted across the line. These adjustable shorts are common at flea markets. Reference 21 describes this technique.

VSWR can be measured with directional couplers but the slotted line shown in **fig. 6C** can also be used. Expensive network analyzers are becoming popular especially with those who work in well-equipped microwave labs. These analyzers present impedance in the graphical form of a Smith chart.[24]

No discussion of impedance matching would be complete without mentioning the Smith chart, developed by the late Phillip H. Smith at Bell Labs. Smith charts basically convert Cartesian coordinates to a system of two orthogonal families of circles. The lines represent contours of constant reactance and resistance. Its use makes impedance matching much easier.

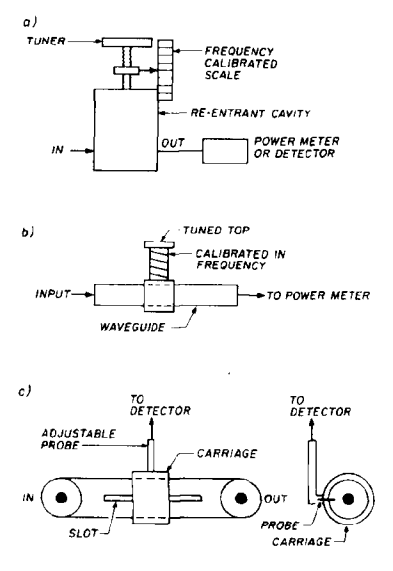


fig. 6. Typical microwave frequency measurement schemes. (A) Absorption wavemeter. (B) Waveguide inline reflection type wavemeter. (C) Slotted line used to probe distance (and hence frequency) between voltage nulls as described in text.

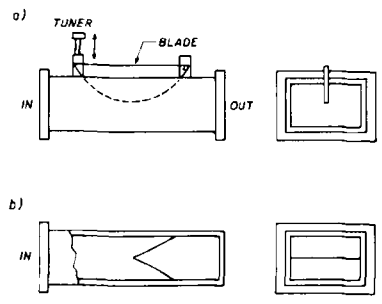


fig. 7. Typical microwave waveguide attenuators and terminations as described in text. (A) Blade type of variable attenuator. (B) Cutaway view of a termination using tapered lossy dielectric.

attenuators and terminations

On frequencies below the microwave bands, attenuators and loads usually consist of a resistor or resistor network. This works fine since good carbon resistors exhibit low reactance. However, as you go higher in frequency, the reactance of most resistors becomes significant and it's no longer a low VSWR (pure) resistance.

Some stripline/microstrip loads and attenuators are available. Manufactured using vacuum deposited nichrome or other suitable materials on a ceramic substrate, they are usually expensive and have frequency limitations. Because of this, other attenuator and termination methods had to be developed on the higher frequencies. Carbon or microwave ferrite-type devices were often used. One special attenuator method was developed for waveguide. It consists of inserting a blade or rotary vane of carbon into the waveguide as shown in **fig. 7A**.

Terminations are another story. Often they are lossy absorbers, not terminations in the true sense of a resistor. **Figure 7B** shows one type consisting of a tapered section of lossy dielectric placed at the end of a waveguide. This type of attenuator can dissipate reasonable power since it's larger than average discrete resistors, but will usually not operate below some cutoff frequency, typically around 1 GHz.

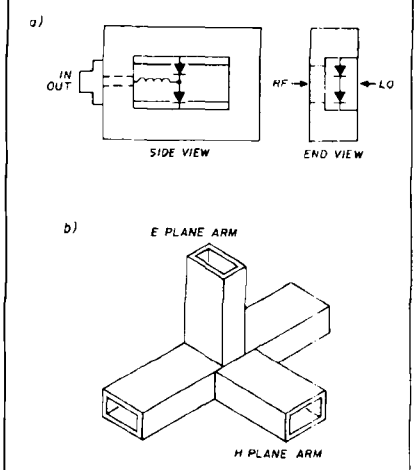


fig. 8. Some microwave waveguide types of balanced mixers. (A) Orthomode. (B) Magic "T".

UHF. Even the subharmonic pumped mixer (where the local oscillator is actually at one-half the normal frequency required) was first used on microwaves.

Balanced mixers with two diodes mounted in series across a waveguide have been around a long time. The Varian OrthoMode™ in **fig. 8A** was one of these. The magic "T" (see **fig. 8B**) was another popular waveguide-type mixer. As noted earlier, this configuration is actually a waveguide coupler. The rat race (**fig. 2G**) and the quadrature coupler (**fig. 2D**) are also used for driving balanced mixers frequently using waveguide.

microwave spectrum analyzers

These instruments really make the life of a microwave engineer a lot easier.

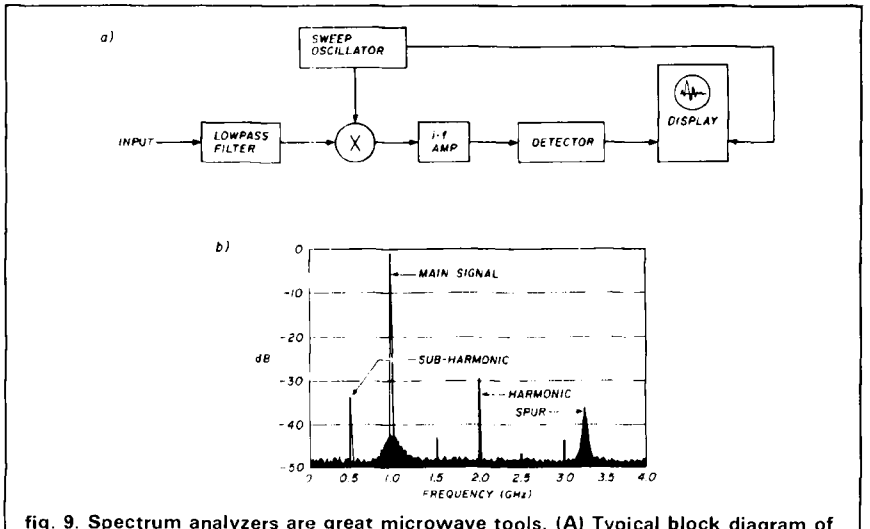


fig. 9. Spectrum analyzers are great microwave tools. (A) Typical block diagram of a spectrum analyzer. (B) A spectrum display of 1.0 GHz local oscillator signal and harmonics, subharmonics, and spurii.

mixers

It wouldn't be fair to skip over microwave mixers since many of the types used today in the VHF/UHF region originally evolved in the microwave region! In fact, one of the first solid-state mixers used a single 1N21 point contact-type diode which became the standard of the radar industry.[16,17] Schottky/hot carrier diodes were first developed for microwaves and later for hf through

The modern spectrum analyzer is similar to present-day hf upconverting superheterodyne receivers. The basic components are a low-pass filter, mixer, sweep oscillator, i-f amplifier, detector, and display as shown in **fig. 9A**

To simplify filtering, input signals are usually upconverted to an i-f above the highest possible input frequency. The signals are then amplified and downconverted to a lower i-f where gain and better selectivity are less expensive.

The detected output is displayed on an oscilloscope.

The beauty of a spectrum analyzer is that all the signal components are displayed so that the relative levels and undesired products are easily discernible (**fig. 9B**). Older spectrum analyzers are now appearing on the surplus market. Sometimes Amateurs who have access to one can help you see what your transmitter or local oscillator's output looks like. Beware; it may scare you!

new VHF records

In last month's column, I mentioned that the 6-meter EME record had been extended.[1] On November 14, 1987, Ray Rector, WA4NJP (EM84DG), worked Jim Treybig, W6JKV (CM87WI), for a new record of 2148 miles (3457 km). Ray used four 8-element W1JR Yagis as described in the May 1987 *ham radio*, and Jim used two of the new 10-element M² (M squared) 50-foot boom length Yagis. Both ran 1500 watts.[27] The QSO took place with the moon setting on Ray's western horizon. To prove it wasn't a fluke, they repeated the contact on November 30th with the moon elevated at both ends. They spent a lot of time and effort to make this all happen. Congratulations again to Ray and Jim. Six-meter EME is now buzzing with activity. How long do you think this record will last?

important VHF/UHF events

April 11	*ARRL 144-MHz Spring Sprint Contest (Monday evening local)*
April 13	*EME perigee*
April 16	*New moon*
April 19	*ARRL 220-MHz Spring Sprint Contest (Tuesday evening local)*
April 21	*Predicted peak of the Lyrids meteor shower at 1730 UTC*
April 27	*ARRL 432-MHz Spring Sprint Contest (Wednesday evening local)*
April 29-May 1	*Dayton Hamvention*
May 4	*Predicted peak of the Eta Aquarids meteor shower at 1900 UTC*
May 6	*ARRL 902-MHz Spring Sprint Contest (Friday evening local)*
May 10	*EME perigee*
May 12	*ARRL 1296-MHz Spring Sprint Contest (Thursday evening local)*
May 13-15	*14th Annual Eastern VHF/UHF Conference, Nashua, New Hampshire (contact W1EJ)*
May 15	*New moon*
May 21-22	*ARRL 50-MHz Spring Sprint Contest (Saturday evening local)*
May 26	*ARRL 2304-MHz Spring Sprint Contest (Thursday evening local)*

references

1. Joe Reisert, W1JR, "VHF/UHF World-Microwave Components and Terminology: Part 1", *ham radio*, March 1988, page 71.
2. Lewis G. McCoy, W1ICP, "The Monimatch", *QST*, October 1956, page 11.
3. Lewis G. McCoy, W1ICP, "Monimatch, Mark II", *QST*, February 1957, page 38.
4. Joe Reisert, W1JAA, "Feeding and Matching Techniques for VHF/UHF Antennas", *ham radio*, May 1976, page 54.
5. Joe Reisert, W1JAA, "Matching Techniques for VHF/UHF Antennas", *ham radio*, July 1976, page 50.
6. Dick Turrin, W2IMU, "The Crawford Hill VHF Club EME Technical Reports, Report #2, Quadrature Hybrid", copies available by arrangement with W2IMU.
7. Henry H. Cross, W1OOP, "The Hybrid Coupler", *ham radio*, June 1982, page 36.
8. Ernie Franke, WA2EWT, "The Branch-line Hybrid: Part 1", *ham radio*, April 1984, page 107.
9. Julius Lange, Texas Instruments, Inc., "Interdigitated Strip-line Quadrature Hybrid", 1969 G-MTT Symposium Digest, page 10-13.
10. Henry S. Keen, W2CTK, "Microwave Hybrids and Couplers for Amateur Use", *ham radio*, July 1970, page 57.
11. Joe Reisert, W1JR, "VHF/UHF World-33 cm-Our Newest Band", *ham radio*, April 1986, page 83.
12. Frederick Emmons Terman, "Electronic and Radio Engineering", McGraw-Hill Fourth Edition, 1955.
13. Bob Scott, W6PUB, "The Traveling-Wave Tube", *QST*, July 1963, page 35.
14. Joe Reisert, W1JR, "VHF/UHF World-Minimum Requirements for 2-Meter EME: Part 2", *ham radio*, September 1987, page 65.
15. Joe Reisert, W1JR, "VHF/UHF World-Loose Ends", *ham radio*, February 1988, page 82.
16. Joe Reisert, W1JR, "VHF/UHF World-The Ubiquitous Diode: Part 1", *ham radio*, February 1987, page 51.
17. Joe Reisert, W1JR, "VHF/UHF World-The Ubiquitous Diode: Part 2", *ham radio*, March 1987, page 55.
18. F.S. Harris, W1FZJ, "The Parametric Amplifier", *CQ Magazine*, November 1958, page 74.
19. Joe Reisert, W1JR, "VHF/UHF World-Low-Noise Receiver Update: Part 1", *ham radio*, November 1987, page 77.
20. Joe Reisert, W1JR, "VHF/UHF World-Low-Noise Receiver Update: Part 2", *ham radio*, December 1987, page 72.
21. Joe Reisert, W1JR, "VHF/UHF World-Impedance-Matching Techniques", *ham radio*, October 1987, page 27.
22. Joe Reisert, W1JR, "VHF/UHF World-RF Connectors: Part 1", *ham radio*, September 1986, page 77.
23. Joe Reisert, W1JR, "VHF/UHF World-RF Connectors: Part 2", *ham radio*, October 1986, page 59.
24. Phillip H. Smith, "Electronic Applications of the Smith Chart", McGraw-Hill, 1969.
25. Joe Reisert, W1JR, "VHF/UHF World-Reflector Antennas: Part 1", *ham radio*, February 1986, page 51.
26. Joe Reisert, W1JR, "VHF/UHF World-Reflector Antennas: Part 2", *ham radio*, March 1986, page 68.
27. Joe Reisert, W1JR, "VHF/UHF World-Optimized 2- and 6-Meter Antennas", *ham radio*, May 1987, page 92.

★ COMPUTER ★ SUPPLIES

Disk File 5 up to 75 5¼ disks	6.95
Media Mate 5 w/lock 5¼	11.95
Library Case up to 10 5¼	2.25
Versa Pak up to 6 5¼	1.95
Micro-Disk 10 up to 10 3½	3.25
★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	
6-Outlet Surge Suppressor	9.99
Curtis Printer Stand	19.99
Computer Tool Kit	22.99
XT System Stand	22.99
Curtis A-B Data Switch	39.99

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

WORLD DATA ENTERPRISES
1-800-634-3547
(305) 551-4023
P.O BOX 652737 MIAMI, FL 33265
*PLUS SHIPPING/HANDLING

175

★DISKETTES★

Bulk 5¼ DSDD w/o Sleeves	.39
Bulk 5¼ DSDD w/Sleeves	.45
Maxell DSDD 5¼	7.99
Maxell DSHD 5¼	22.99
Nashua DSDD 5¼	9.99
Nashua DSHD 5¼	16.99
3M DSDD 5¼	12.99
3M DSHD 5¼	22.99
Maxell 3½ DSDD	24.99
3M 3½ DSDD	22.99

WORLD DATA ENTERPRISES
1-800-634-3547
(305) 551-4023
P.O BOX 652737 MIAMI, FL 33265
*PLUS SHIPPING/HANDLING

CADDELL COIL CORP.
35 Main Street
Poultney, VT 05764
802-287-4055

BALUNS

Get POWER to your antenna! Our Baluns are already wound and ready for installation in your transmatch or you may enclose them in a weatherproof box and connect them directly at the antenna. They are designed for 3-30 MHz operation. (See ARRL Handbook pages 19-9 or 6-20 for construction details.)

100 Watt (4:1, 6:1, 9:1, or 1:1 impedence—select one)	$10.50
Universal Transmatch 1 KW (4:1 impedence)	14.50
Universal Tranamatch 2 KW (4:1 impedence)	17.00
Universal Transmatch 1 KW (6:1, 9:1, or 1:1—select one)	16.00
Universal Transmatch 2 KW (6:1, 9:1, or 1:1—select one)	18.50

Please send large SASE for info.



DX FORECASTER

Gerth Stonehocker, KØRYW

dx signal quality

Most DXers become quite proficient at copying weak, varying signals through QRM and noise. A greater occurrence of geomagnetic ionospheric disturbances with accompanying fading during the equinox season really makes one work. Studies on fading and signal quality may provide information allowing you to operate more effectively during this season.

Fading is characterized by the time interval between signal crests or troughs and by the amplitude change between these peaks and valleys, commonly called depth of fade. It is often accompanied by frequency distortion which is also used to characterize signal quality. Fade rate is defined as *intervals* per second. Signal fade can appear as either a decrease in (attenuation) strength or an increase (focusing) of signal amplitude. Flutter is a rapid fade rate in which several intervals (cycles) occur per second. One interval per second is called a fast fade, and intervals of several seconds or longer are known as long fades. *Flat fading* involves no frequency distortion, and *selective fading* includes frequency distortion within the bandwidth being used.

Most of the attenuation associated with fading occurs as the signal passes through the D and E regions of the ionosphere where the numbers of electrons are greatest, but electron motion becomes turbulent at times of disturbed geomagnetic fields. Fading depth and duration are not great from these regions.

The significant focusing and frequency fading characteristics come mainly from the F region of the ionosphere. Here fade depth and duration can attain any set of values between extremes. Signal variability is a function of distance since a great number of hops averages out the amplitude extremes. As distance between the transmitter and receiver increases the take-off angle lowers; that factor plus the multihop path both tend to lengthen the fade interval. For a *set* distance, the duration between fades *decreases* with the higher take-off angle if you increase the number of hops.

During the first few hours (positive phase) of disturbed geomagnetic field conditions in mid-latitudes, the fade interval is shorter than normal and lengthens to longer than normal in the remaining hours (negative phase). It slowly approaches normal values again in two to three days. Conversely, the fade rate is usually higher than normal during those first hours, sometimes up to a day, then slowly returns to normal in the remaining ones. This sequence is reversed in phase at lower latitudes closer to the geomagnetic equator. The extent to which fading affects communications also depends on the signal modulation that's employed. The type of communications least affected are CW, voice, and teletype respectively. As a general rule, higher speed data transmission is most affected. The ease of overcoming this difficulty depends on the speed (bit or mark/space length), the amount of redundancy built into the modulation, and the modulation type (FSK or PSK, coherent/synchronous or asynchronous, and the bit structure). The system can be designed to operate well in fixed links. The predominant type of fading can be overcome by tailoring the speed, redundancy, and modulation form to suit. For the most part, DXers have lived with fading for years and know almost instinctively the best mode to use "to get through". For most of us old DXers it is just CW with an occasional missing dit or dah.

last-minute forecast

The lower frequency bands, for daytime short skip and nighttime DX, should be excellent during the first and last weeks of the month. Winter (low) noise conditions still prevail helping these lower bands, except during spring weather-front thunderstorm passages. Equinox geomagnetic disturbances may reduce MUFs around April 2, 11, 21, and 29, especially at night. The higher bands will be very good the middle two weeks of the month. Look for transequatorial openings to southern countries especially during geomagnetic disturbances when MUFs increase in the local afternoons and evenings.

The perigee of the moon's orbit (for moonbounce DX) is on the 13th, with the moon at full phase on the 2nd. There will be a short meteor shower, the Lyrid, on April 20-22 with a rate of five per hour — hardly much help for meteor-scatter DX. But a bigger shower, the Aquarid, starts before the end of April, peaks on the 5th of May, and ends in mid-May. Its rate is 10 to 30 per hour.

band-by-band summary

Ten meters will be open to the south and southeast for an hour before local noon, to the south at noon and to the southwest in the afternoon. The openings will be longer when the solar flux is at its 27-day cycle maximum. Transequatorial openings are also best at that time.

Fifteen and 20 meters, almost always open to some part of the world, will be the main daytime DX bands.

WESTERN USA

GMT	PST	N	NE	E	SE	S	SW	W	NW
0000	4:00	20	15	15	10	15	10	12	15
0100	5:00	20	15	15	10	15	10	10	15
0200	6:00	20	15	15	10	15	10	10	15
0300	7:00	20	20	20	10	20	10	10	15
0400	8:00	20*	20	20	10	20	12	12	15
0500	9:00	15	20	20	12	20	12	12	15
0600	10:00	15	20	20	12	20	12	15	20
0700	11:00	15	*20*	20	15	20	12	15	20
0000	12:00	15	*30*	20	15	20	15	15	20
0900	1:00	*30*	*30*	*20*	15	*30*	15	15	20
1000	2:00	*30*	*30*	*20*	*20**	*30*	15	20	20
1100	3:00	*30*	*30*	*20*	*20*	*30*	*20*	20	*30*
1200	4:00	*30*	*20*	15	*20*	*30*	*20*	*20*	*30*
1300	5:00	*30*	*20*	15	*20*	*30*	*20*	*20*	*30*
1400	6:00	*30*	20	15	20	*20*	*20*	*20*	*30*
1500	7:00	30	20	15	20	*20*	*20*	*20*	*30*
1000	8:00	30	20	12	20	*20*	20	20	*30*
1700	9:00	30	20	12	20	*20*	15	20	20
1800	10:00	30	20	10	15	*20*	15	20	20
1900	11:00	30	20	10	15	15	15	15	20
2000	12:00	20	15	10	15	15	12	15	20
2100	1:00	20	15	10	15	15	12	15	20
2200	2:00	20	15	12	12	15	12	15	20
2300	3:00	20	15	15	12	15	10	12	20

MID USA

MST	N	NE	E	SE	S	SW	W	NW	CST
5:00	20	15	15	15	15	10	12	15	6:00
6:00	20	20	15	15	15	10	10	15	7:00
7:00	20	20	15	15	15	10	10	15	8:00
8:00	30	20	20	20	20	10	10	15	9:00
9:00	30	20	20	20	20	12	12	15	10:00
10:00	*30*	20	20	20	20	12	15	15	11:00
11:00	*30*	20	20	20	20	12	15	20	12:00
12:00	*30*	*30*	20	*20*	20	15	15	20	1:00
1:00	*20*	*30*	*20*	*20*	*30*	15	15	20	2:00
2:00	*20*	*30*	*20*	*20*	*30*	15	20	20	3:00
3:00	*20*	*30*	*20*	*20*	*30*	*20*	20	*30*	4:00
4:00	*20*	*30*	*20*	*15*	*30*	*20*	*20*	*30*	5:00
5:00	*20*	*30*	15	15	*30*	*20*	*20*	*30*	6:00
6:00	20	20	15	15	*30*	*20*	*20*	*30*	7:00
7:00	20	20	15	15	*20*	*20*	*20*	*30*	8:00
8:00	20	20	15	12	*20*	*20*	*20*	*30*	9:00
9:00	15	20	12	12	*20*	20	20	20	10:00
10:00	15	20	12	10	*20*	15	20	20	11:00
11:00	15	20	10	10	*20*	15	20	20	12:00
12:00	15	20	10	10	15	15	15	20	1:00
1:00	15	20	10	10	15	12	15	20	2:00
2:00	20	20	12	12	15	12	15	20	3:00
3:00	20	15	15	15	15	12	12	20	4:00
4:00	20	15	15	15	15	10	12	20	5:00

EASTERN USA

EST	N	NE	E	SE	S	SW	W	NW
7:00	20	20	15	15*	15	10	10	15
8:00	20	20	15	15	15	10	10	15
9:00	30	20	15	15	15	10	10	15
10:00	30	20	20	15	20	10	12	15
11:00	30	20	20	20	20	12	12	15
12:00	30	20	20	20	20	12	15	15
1:00	*30*	*30*	20	20	20	15	15	20
2:00	*30*	*30*	20	20	20	15	15	20
3:00	*20*	*30*	*20*	*20*	*30*	15	20	20
4:00	*20*	*30*	*20*	*20*	*30*	*20*	20	*30*
5:00	*20*	*30*	*20*	*20*	*30*	*20*	*20*	*30*
6:00	*20*	*30*	*20*	*20*	*30*	*20*	*20*	*30*
7:00	*20*	20	15	*15*	*30*	*20*	*20*	*30*
8:00	*20*	20	15	15	*30*	*20*	*20*	*30*
9:00	20	20	15	12	*20*	*20*	*20*	*30*
10:00	20	20	12	12	*20*	20	20	*30*
11:00	15	20	12	10	*20*	15	20	*30*
12:00	15	20	10	10	*20*	15	20	20
1:00	15	20	10	10	*20*	15	20	20
2:00	15	20	10	12	15	15	15	20
3:00	15	20	12	12	10	12	15	20
4:00	20	20	15	12	15	12	15	20
5:00	20	20	15	15	15	12	12	20
6:00	20	20	15	15	15	10	12	20

APRIL

	N	NE	E	SE	S	SW	W	NW
ASIA FAR EAST	20	15	15	10	15	10	12	15
EUROPE	20	15	15	10	15	10	10	15
S. AFRICA	20	15	15	10	15	10	10	15
S. AMERICA	20	20	20	10	20	10	10	15
ANTARCTICA	20	20	20	10	20	12	12	15
NEW ZEALAND	15	20	20	12	20	12	12	15
OCEANIA AUSTRALIA	15	20	20	12	20	12	15	20
JAPAN	15	20	20	12	20	12	15	20

	N	NE	E	SE	S	SW	W	NW
ASIA FAR EAST	20	15	15	15	15	10	12	15
EUROPE	20	20	15	15	15	10	10	15
S. AFRICA	20	20	15	15	15	10	10	15
S. AMERICA	30	20	20	20	20	10	10	15
ANTARCTICA	30	20	20	20	20	12	12	15
NEW ZEALAND	30	20	20	20	20	12	15	15
OCEANIA AUSTRALIA	30	20	20	20	20	12	15	20
JAPAN	30	20	20	20	20	15	15	20

	N	NE	E	SE	S	SW	W	NW
ASIA FAR EAST	20	20	15	15*	15	10	10	15
EUROPE	20	20	15	15	15	10	10	15
S. AFRICA	30	20	15	15	15	10	10	15
CARIBBEAN S. AMERICA	30	20	20	15	20	10	12	15
ANTARCTICA	30	20	20	20	20	12	12	15
NEW ZEALAND	30	20	20	20	20	12	15	15
OCEANIA AUSTRALIA	30	30	20	20	20	15	15	20
JAPAN	30	30	20	20	20	15	15	20

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next **higher** band for possible openings.

RF POWER TRANSISTORS

We stock a full line of Motorola & Toshiba parts for amateur, marine, and business radio servicing

SEE YOU AT DAYTON BOOTH 360

Partial Listing of Popular Transistors

2-30 MHz 12V. (28V)*

P/N		Rating	Net Ea.	Match Pr.
MRF421	Q	100W	$24.00	$53.00
MRF422*		150W	36.00	78.00
MRF454, A	Q	80W	14.50	32.00
MRF455, A	Q	60W	11.75	26.50
MRF485*		15W	6.00	16.00
MRF492	Q	90W	16.00	35.00
SRF2072	Q	65W	12.75	28.50
SRF3662	Q	110W	24.00	53.00
SRF3775	Q	75W	13.00	29.00
SRF3795	Q	90W	15.50	34.00
SRF3800	Q	100W	17.50	38.00
2SC2290	Q	80W	16.75	39.50
2SC2879	Q	100W	22.00	48.00

Q Selected High Gain Matched Quads Available

VHF UHF TRANSISTORS 12V.

	Rating	MHz	Net Ea.	Match Pr.
MRF245	80W	136-174	27.50	61.00
MRF247	75W	136-174	26.00	58.00
MRF248	80W	136-174	33.00	71.00
MRF641	15W	407-512	18.00	42.00
MRF644	25W	407-512	21.00	46.00
MRF646	40W	407-512	25.00	54.00
MRF648	60W	407-512	31.00	66.00
2N6080	4W	136-174	6.25	—
2N6081	15W	136-174	8.00	—
2N6082	25W	136-174	9.50	—
2N6083	30W	136-174	9.75	24.00
2N6084	40W	136-174	11.50	28.00

PARTIAL LISTING OF MISC. TRANSISTORS

MRF134	$16.00	MRF515	2.50
MRF136	21.00	MRF607	2.50
MRF137	24.00	MRF630	4.25
MRF138	35.00	MRF846	43.50
MRF174	80.00	MRF1946,A	14.00
MRF208	11.50	CD2545	16.00
MRF212	16.00	SD1278-1	17.75
MRF221	11.00	2N3553	2.29
MRF224	13.50	2N3866	1.25
MRF237	2.70	2N4427	1.25
MRF238	12.50	2N5589	7.25
MRF239	14.00	2N5590	10.00
MRF240	15.00	2N5591	13.50
MRF260	7.00	2N5641	9.50
MRF261	8.00	2N5642	13.75
MRF262	8.75	2N5643	15.00
MRF264	12.50	2N5945	10.00
MRF309	29.75	2N5946	12.00
MRF317	56.00	2SC1946,A	15.00
MRF406	12.00	2SC1947	9.75
MRF433	11.00	2SC2075	3.00
MRF449	12.50	2SC2097	28.00
MRF450	13.50	2SC2509	9.00
MRF453	15.00	2SC2640	15.00
MRF458	20.00	2SC2641	16.00
MRF475	3.00	*OUTPUT MODULES*	
MRF476	2.75	SAU4	55.00
MRF477	11.75	SAU17A	50.00
MRF479	10.00	SAV6	42.50
MRF492A	18.75	SAV7	42.50
MRF497	14.25	SAV15	48.00
40582	7.50	M57712, M57733	use SAV7
NE41137	2.50	M57737, SC1019	

Hi-Gain, Matched, and Selected Parts Available

We stock RF Power transistors for Atlas, KLM, Collins, Yaesu, Kenwood, Cubic, Mirage, Motorola, Heathkit, Regency, Johnson, Icom, Drake, TWC, Wilson, GE, etc. Cross-reference on CD, PT, SD, SRF, JO, and 2SC P/Ns.

Quantity Pricing Available Foreign Orders Accepted

Shipping/Handling $5.00 COD VISA MC

Orders received by 1 PM PST shipped UPS same day. Next day UPS delivery available

ORDER DESK ONLY — NO TECHNICAL

(800) 854-1927

ORDER LINE and/or TECH HELP

(619) 744-0728

FAX (619) 744-1943

RF PARTS

1320 Grand Avenue
San Marcos, CA 92069

2x4Z BASE REPEATER ANTENNA

THE HIGHEST GAIN DUAL BAND BASE/REPEATER ANTENNA

HIGH POWER 200 WATTS

CENTER FREQUENCY
146.500 MHz
446.500 MHz

GAIN:
VHF - 8.2dB
UHF - 11.5dB
VSWR - 1.-1.2 or less

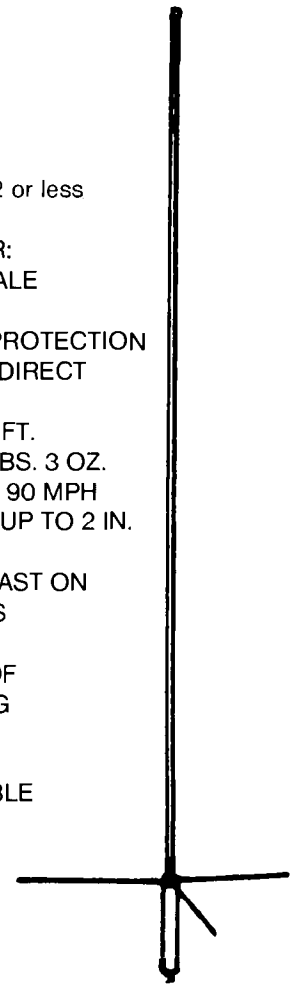
CONNECTOR:
N TYPE FEMALE

LIGHTNING PROTECTION
GROUNDED DIRECT

LENGTH: 16 FT.
WEIGHT: 5 LBS. 3 OZ.
WIND LOAD: 90 MPH
MOUNTING: UP TO 2 IN. MAST
CAN SIMULCAST ON BOTH BANDS

WATERPROOF CONNECTING JOINTS

UPS SHIPPABLE



AMATEUR SPECIAL

NCG

1275 NORTH GROVE ST.
ANAHEIM, CALIF. 92806
(714) 630-4541

CABLE: NATCOLGLZ
FAX (714) 630-7024

176

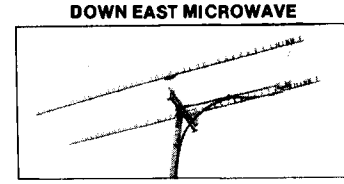
Twenty should stay open on long southern paths into the night, while 15 will drop out in the late afternoon. DX is 5000 to 7000 miles (8000-11,200 km) on these bands and one-long-hop transequatorial propagation is also possible as on 10 meters.

Thirty and 40 meters are both day and night bands. Intermediate distances (1000-1500 miles, 1500-2200 km) in any direction represent daytime DX. Nighttime DX on these bands may be expected to offer a greater distance than on 80 meters and, like 80, follow the darkness path across the sky. Reduced midday signal strengths and distances may occur on days of high solar flux values.

Eighty and 160 meters will exhibit short skip conditions during daylight hours and lengthen for DX at dusk. These bands follow the darkness path, opening to the east just before local sunset, swinging more to the south near midnight, and ending up in the Pacific areas shortly before dawn. The 160-meter band opens later and ends earlier.

ham radio

DOWN EAST MICROWAVE



MICROWAVE ANTENNAS AND EQUIPMENT

• Loop Yagis • Power Dividers • Linear Amplifiers • Complete Arrays • Microwave Transverters • GaAsFET Preamps • TROPO • EME • Weak Signal • OSCAR • 902 • 1269 • 1296 • 2304 • 2400 • 3456 MHz

2346 LY	45el	loop Yagi	1296 MHz	20dBI	$93
1346 LY	45el	loop Yagi	2304 MHz	20dBI	$80
3333 LY	33el	loop Yagi	902 MHz	18.5dBI	$93

Above antennas assembled and tested. Kits available.
All Aluminum and Stainless Construction.
Add $8 UPS S/H, 311 West of the Mississippi.
2316 PA Linear Amp 1W In 18W out 1296 MHz 13.6V. $245 ppd.
2336 PA Linear Amp 10W In 35W out 1296 MHz 12.6V. $295 ppd.

NEW! MICROWAVE TRANSVERTERS BY LMW ELECTRONICS

1296TRV6D 6W, GaAsFET, T/R Sequencer, Output Meter $569
2304TRV2D 2W, GaAsFET, T/R Sequencer, Output Meter $649

Add $6 for shipping UPS/48
Stripped down version, kits also available
Write For FREE Catalog

VISA **DOWN EAST MICROWAVE** MasterCard
Bill Olson, W3HOT
Box 2310, RR 1, Troy, ME 04987
(207) 948-3741

177



ELMER's NOTEBOOK

Tom McMullen, W1SL

antenna tuner

In last month's Notebook I discussed transmission lines and their construction and impedance. The May 1988 *ham radio* is the annual antenna issue, so next month's column will focus on that subject. In this issue, let's look at another part of a transmitting/receiving system — the "antenna tuner".

Most everyone calls the device used by Amateurs between their station and the antenna an "antenna tuner", even though this isn't really what it is. The proper term is *impedance-matching circuit*, but that just doesn't turn people on the way "antenna tuner" does. In earlier days, the circuitry used to get an antenna to "load" was an antenna tuner of sorts; the end of the antenna was brought right into the shack and tapped on the tuned circuit. Adjustments were made by changing the coupling link from the transmitter and moving the antenna tap on the coil, **fig.1**.

This system worked, and still does, but it has faults. For one, it brings a lot of rf right into the shack. This was okay in the days of vacuum tubes that were not too sensitive to the presence of rf, but stray rf certainly creates big problems with today's semiconductors, not to mention nearby TV and hi-fi sets.

Getting the antenna out of the shack and up in the air had two desirable results: it reduced the rf problem and improved radiation by being in the clear, away from nearby objects. This created the need for a transmission line to conduct power between the transmitter and the antenna, but did not eliminate the need for some type of matching device at the transmitter output. No two antennas are alike in installation, environment, construction, or impedance and method of feed, and what works well on one band is not necessarily the optimum choice for another. Operation over a wide portion of any band creates another problem. You can make the length of an antenna correct for one part of a band but it is not resonant in another part, so if you move your operating frequency very far you'll see the VSWR start to climb. Some rigs will put up with this, but many will not.

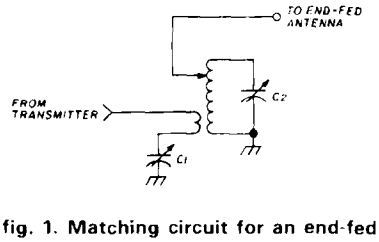


fig. 1. Matching circuit for an end-fed wire antenna. The tap is moved along the coil until the transmitter is properly loaded.

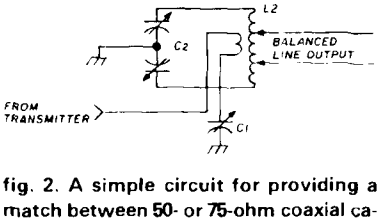


fig. 2. A simple circuit for providing a match between 50- or 75-ohm coaxial cable and parallel-wire transmission line of any impedance.

Enter the impedance-matching circuit, sometimes called a "Transmatch" or "antenna Coupler" or "antenna Tuner."

A basic circuit is shown in **fig. 2**. The simple tuned circuit has a link to couple energy from the transmitter to it, and taps on the coil for matching to twin-lead transmission line. This type is ideal when you have a center-fed dipole with a feedline of TV ribbon or open-wire "ladder line." The capacitor (C_1) in series with the link "tunes" it for maximum coupling of energy from the transmitter. C_2 and L_2 form a resonant tank at the operating frequency. The taps are simply moved equal distances from the center of the coil until the transmitter shows proper loading.

A "Transmatch" or "Ultimate Transmatch" is another all-purpose tuner. It one of the most useful, wide-range matching circuits in Amateur radio, and has several variations. The basic circuit is shown in **fig. 3.** The transmitter input is coupled to the circuit by C_1, and the combination of variable capacitance of C_1, inductance L_1, and the output capacitor C_2 provide matching for a load that can be anything from 50-ohm coaxial cable to open-wire line or a single-wire end-fed antenna (if you still want to bring rf back into the shack).

The inductance (L_1) for this kind of circuit is usually variable, consisting of

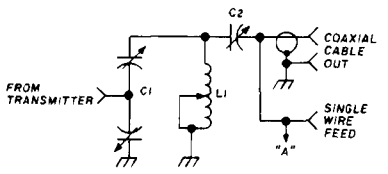


fig. 3. A versatile Transmatch type of matching circuit. The variable capacitors and inductor allows it to perform over a wide range of frequencies and impedances. As shown here, the output will accept either coaxial cable or single-wire feed (as for an end-fed antenna).

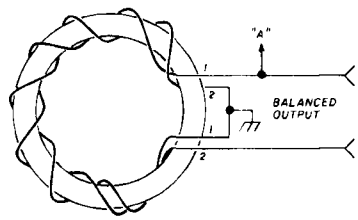


fig. 4. A balun transformer is a useful addition to the Transmatch circuit. The point labeled "A" connects to "A" in *fig. 3.*

turns of wire on a ceramic cylinder that can be rotated by a knob on a panel. The tap is a roller that contacts the turns of the wire as the inductor is rotated providing a continuously variable inductance which (along with C_2) matches a wide range of impedances. A variation of this circuit uses a tapped inductor and a well-insulated switch to select the proper value, eliminating the hard-to-find roller inductor.

A balun transformer allowing connection to a balanced line is a useful addition to this Transmatch circuit; one is shown in **fig. 4.** It can be built into the same enclosure as the Transmatch, or as a separate unit and attached to the coaxial connector. If you build it into the Transmatch circuit enclosure, connect the points shown as "A" in **figs. 3** and **4.** The transformer is wound on a ferrite core.

Commercial Transmatches are available but they are not difficult to construct in the home workshop. Looking for the roller inductors and variable capacitors to build a Transmatch is a favorite pastime of Amateurs at hamfests and flea markets. It is a popular project.

There are other circuits that can be used to match impedances; two of the most common are the "L" network and the "Pi" network in **fig. 5.** The L network is useful for matching a low impedance to a high one. The lower impedance must always be connected to the inductance end of the circuit and the higher impedance must always be across the capacitor. This circuit

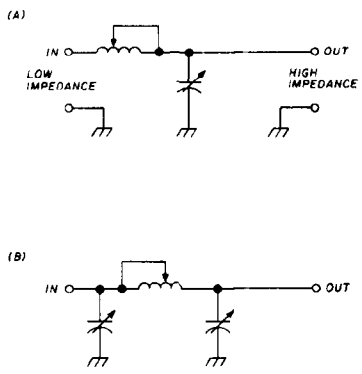


fig. 5. The L network, at A, is useful for matching some types of antennas, particularly a vertical radiator where the circuit is placed at the base. The Pi circuit at B will match a very wide range of input and output impedances. It can accept low or high impedances at either the input or output.

works well as an "antenna tuner", placed at the base of a vertical antenna and adjusted to provide a match between the antenna and the feedline to the transmitter.

The Pi network covers the widest range of any common circuit, and was for years the mainstay of impedance-matching techniques. Many transmitters used this type of circuit at the output of the power amplifier, and it was said that they would "match anything". I can personally attest to one trial to see if this was true.

In Willimantic, Connecticut, three of us decided one evening to see if this circuit really would (as a popular saying of the time claimed) "load a piece of wet string". We soaked some heavy twine in a bucket of salt water and quickly connected it to the network, suspending the far end over the limb of a convenient tree. We made a contact on 20 meters, but the rf power kept drying out the string so we had to re-wet it while our operator was receiving. He then waited for our "ready" yell before transmitting. I don't think the guy at the other end of the contact ever believed us, even when he got the QSL card listing the antenna as "1/2-wave wet string"!

The Pi network is bi-directional; either end can be the high- or low-impedance port.

receiver benefits from matching (circuit)

In addition to the impedance-matching, these circuits also reduce harmonics that might otherwise get to the antenna and be radiated. Also, when the selective circuit is placed between the antenna and the receiver, interference from strong stations outside the Amateur bands is reduced. Receivers, like transmitters, do perform better when their input impedance is properly matched.

It is important to remember that none of these circuits change your antenna impedance or reduce the VSWR on the transmission line feeding your antenna. If your dipole on 15 meters looks like 7-1/2 ohms at the feedpoint, absolutely nothing you do in your shack will change that. Likewise, if the VSWR on the transmission line is 15:1, it is going to stay there no matter what kind of "matcher" you use. The main function of a matching circuit in your shack is to present your transmitter with a proper load. Any VSWR problems on the feedline can be cured only by working on the antenna itself or by placing a matching circuit right at the antenna feedpoint. It's okay if the VSWR is moderate — systems with 3:1 or 4:1 on the line between the antenna and the Transmatch do their job just fine. At values higher than that, you are losing some power in the feedline and perhaps radiating some of it

from the line rather than the antenna, so some antenna work is in order.

operating practices

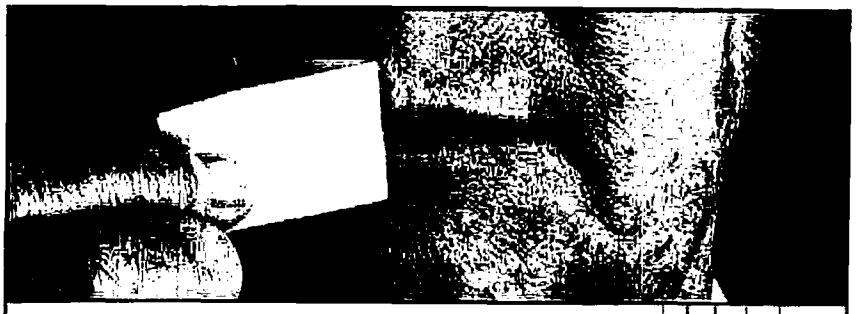
No one likes to hear stations tuning up in the middle of their QSO, but these circuits do require adjustment from time to time. Here are a few tips to make life easier for everyone:

- On most matchers, the variable capacitors and inductors have calibrated knobs, dials, or multiturn indicators. Make a calibration chart or marks on the panel listing the tuning positions for each of your favorite bands and operating frequencies. Then you will need to make only minor adjustments, or perhaps none at all, when you change frequency.
- Initial tuning and calibrating of the Transmatch should be done when a particular band is dead, using the lowest value that your power and SWR meters will accurately indicate. Your VSWR is not going to change if you tune up with 5 watts and then use 200 for QSOs.
- Do your initial tuning of the transmitter only into a dummy load, then switch to the matching network. From then on, make minor adjustments of the matching network to keep the transmitter happy; don't readjust the transmitter tuning. Some Transmatches have a built-in switch to select a dummy load, and a power/SWR meter to aid in tune-up. Both are worthwhile additions if you build your own.

the other side of the coin

On the other hand, Transmatches (and all matching networks, for that matter) lose some of the power on the way through. Circuits constructed with quality components — heavy or silver-plated wire, and inductors and capacitors with steatite or ceramic insulation — have losses small enough to ignore. Poor insulation and small wire can increase losses significantly. Also, some circuits are built using toroidal transformers and if their core material is not meant for use at the frequency of operation, the losses will be large.

ham radio

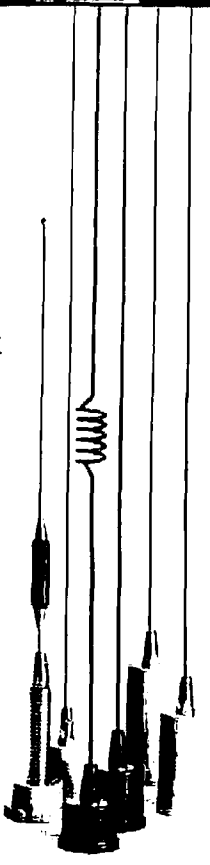


Now that you can speak, talk to Larsen.

Novice Enhancement opens up a whole new way for novices to communicate. To make the most of it, talk to Larsen Electronics.

We'll tell you how Larsen antennas can greatly improve your powers of communication. We'll also explain how Larsen 220 and 1296 MHz antennas are designed to give you the best performance.

Talk to your Larsen amateur dealer today, and see if Larsen performance doesn't speak for itself.



Larsen Antennas
The Amateur's Professional™

See your favorite amateur dealer or write for a free amateur catalog

IN USA: Larsen Electronics, Inc., 11611 N.E. 50th Ave., P.O. Box 1799, Vancouver, WA 98668, 206-573-2722.
IN CANADA: Canadian Larsen Electronics, Ltd., 149 West 6th Avenue, Vancouver, B.C. V5Y 1K3, 604-872-8517.

178

BEVERAGE ANTENNA HANDBOOK

by Vic Misek, W1WCR New Edition

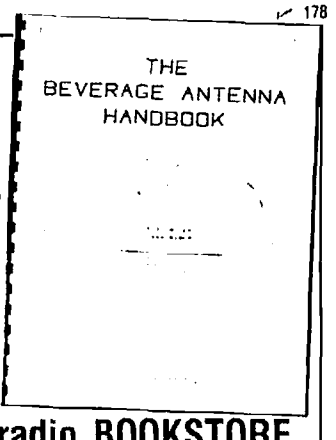
W1WCR has spent countless hours developing new antenna ideas and optimizing the SWA (Steerable wave antenna.) Misek delves deep into the secrets of the single wire Beverage with helpful hints and tips on how to maximize performance based upon wire size, height above ground, overall length and impedance matching. Also includes information on center fed Beverages constructed out of several wire types. SMALL LOT OWNERS Beverage for you too! Called the Micro SWA, it is just 60 ft long. You get excellent directivity and null steering capabilities. Transformer design information for both termination and feedline matching is completely revised. 1987 80 pages.

VM-BAH Softbound $14.95

Please enclose $3.50 shipping & handling

BRAND NEW

FULLY REVISED



ham radio BOOKSTORE
GREENVILLE, NH 03048 603-878-1441



new pocket HTs from Kenwood

The new Kenwood TH-25 Series HT is compact with wideband frequency coverage, big LCD display, and 5 watts output option.

Operating features include: front panel DTMF pad, automatic power control, 14 memories, automatic offset selection, band and memory scan, automatic "power off" circuit, and CTCSS encode/decode option. Accessories supplied with the unit are: StubbyDuk, battery pack, wall charger, bolt hook, wrist strap, and water resistant dust caps.

Contact Kenwood Amateur Radio dealers for details and information on accessories. The suggested retail price for the TH-25AT is $329.95; the TH-45AT is priced at $349.95.

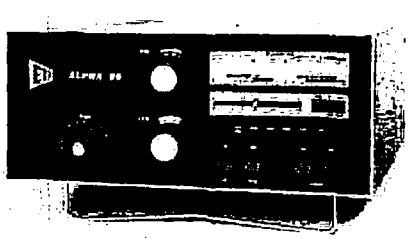
ALPHA linear amplifiers

Ehrhorn Technological Operations has introduced a new ALPHA line of linear amplifiers.

The ALPHA 86 features 1500 watts output power, PIN diode T/R switching for full QSK, and easy tune-up. It maintains full output in any mode with no key-down time limit and uses a pair of Eimac's 3CX800A7 tubes.

The ALPHA 87 needs no tune-up; factory pretuned bandpass circuits allow instant QSY to any hf band.

The ALPHA 88 is a fully automatic version of the ALPHA 86. A microprocessor is preprogrammed at the factory for all Amateur bands. The ALPHA 88 samples the input frequency and automatically tunes the tank circuits.



For more information contact Ehrhorn Technological Operations, Inc., P.O. Box 888, 451 Valley Road, Canon City, Colorado 81212.

Circle #301 on Reader Service Card.

new Hamtronics catalog

Hamtronics, Inc. 1988 catalog has kits and wired units for Amateur radio, two-way shops, and scientific and industrial radio users. New product listings include: R901 fm receiver for 902-928 MHz, R137 weather satellite receiver for the 137-MHz band, an AP3 repeater autopatch module, 70-watt hi-band and UHF repeater power amplifiers, and a complete system for 9600 baud packet radio linking.

To order send $1 ($2 for overseas) to Hamtronics, Inc., 65-F Moul Road, Hilton, New York 14468-9535.

new antennas, solar power supply

The QRV 160-10 is a low-visibility, all-band hf antenna originally created for rapid emergency installation. Thanks to special kinkproof wire, installation can easily be completed by a single individual. Insulated and completely weather-sealed, the QRV 160-10 may be connected directly to a transceiver or a transmatch by means of its PL 259 connector. The feedline may be extended as necessary with 50-ohm coaxial line. Based on the popular G5RV design, the QRV 160-10 measures 102 feet from end to end, and can be installed in dipole, V, sloper, or folded configurations. Unique adjustable insulators facilitate bending to fit available space. An extensive technical manual explains how to obtain desired results from difficult installation sites, including spans as short as 26 feet. The QRV 160-10 is rated for full legal power. It comes ready to use, and is priced at $49.95, including U.S. delivery.

AntennasWest has also introduced its QRV-Solar 23 Solar Power Supply, designed to provide independent power for remote repeaters, portable or RV-based stations, and hamshack installations. The heart of the system is an easily installed, unbreakable and bullet-tested solar panel with unique linear current boosting circuitry. Rated at 23 watts, the QRV-Solar 23 delivers 1.65 amperes at 14 volts and increased current at lower voltages.

The QRV-Solar 23 is available for immediate delivery from AntennasWest at $289.95 postpaid. An optional kit for mounting on vertical masts is available at $34.95.

For further information on these new products, contact AnntennasWest, 1971 North Oak Lane 1300, Provo, Utah 84604-2138.

Circle #302 on Reader Service Card.

HL-250U linear amplifier

The HL-250U is a high-power linear amplifier for Amateur UHF band all mode operation. It provides a maximum output power of 250 watts when driven by any 10 or 25 watt radio through the automatic drive level select circuit. The HL 250U is solid state, requires no tuning, has forced air cooling with stable output and high voltage safety measures provided. The built-in low-noise GaAsFET receive pre-amp enables comfortable UHF DX QSOs.

The suggested retail price of the HL 250U is $824.95. For more information contact ENCOMM, Inc., 1506 Capital Avenue, Plano, Texas 75074.

Circle #303 on Reader Service Card.

antenna design and construction aid

A new approach to antenna design and construction is offered by Epsilon Company. It is the only antenna design program featuring a sinusoidal projection of the antenna's radiation pattern. This approach shows the signal intensity at all angles, horizontal and vertical of the antenna simultaneously, referenced to isotropic. It's like sitting in a planetarium. At the center of the floor is your antenna which is the only source of light. The dome or sky is illuminated according to signal intensity at each point. Long Wire Pro's sinusoidal projection is a sophisticated flat projection of the sky, color coded according to signal intensity. You can explore the projection with a mouse or cursor keys and read in a numeric window the gain at a particular azimuth and elevation.

Long Wire Pro lets you select wire lengths, for center-fed and end-fed long wires, Vee's, and rhombics. Next choose the height above ground, the kind of ground, such as moist, dry, average, etc. Then enter the slant of the antenna over ground.

The projection is then drawn in the center of the screen. Above this is a window showing a table of the antenna's parameters you've entered along with the maximum gain, azimuth, and elevation referenced to isotropic, the overall dimensions, and in the case of terminated antennas, the recommended termination resistor. All this can be printed on a dot matrix printer.

One can simulate many antennas in less than ideal real conditions. Odd wire lengths, antenna slants, and low ground conductivity are all conditions that cause radiation pattern to change from published patterns.

Long Wire Pro runs on IBM-PC/XT/AT's and compatibles with 256K or more, DOS 2.0 or higher, and color is required. It makes use of 8087/80287 math co-processor if present, and also a mouse if present. The disk contains two files, one will run on 160K RAM, and the other on 450K of RAM. The small version is intended to run on 256K computers and has 3 degree resolution. The large file's program has 1 degree resolution. In all other respects they are the same.

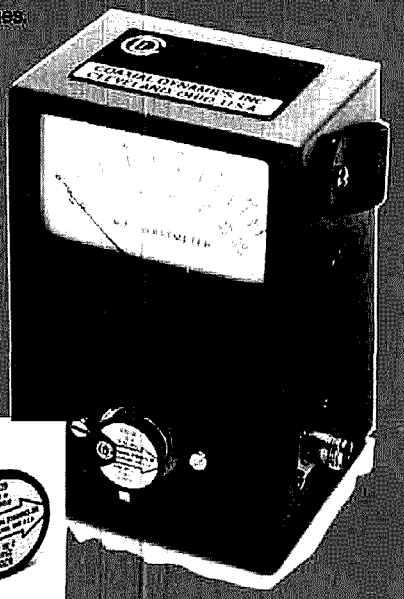
Epsilon is selling Long Wire Pro for $35.00, and it can be ordered from Epsilon Co., P.O. Box 715, Trumbull, Connecticut 06611.

Circle #306 on Reader Service Card.

Measure Up With Coaxial Dynamics Model 81000A RF Directional Wattmeter

Model 81000A is a thoroughly engineered, portable, insertion type wattmeter designed to measure both FWD/RFL C.W. power in Coaxial transmission lines. 81000A is comprised of a built-in line section, direct reading 3-scale meter protected by a shock-proof housing. Quick-mate connectors, plus a complete selection of plug-in elements, gives the FRONT RUNNER reliability, durability, flexibility and adaptability with a two year warranty.

Contact us for your nearest authorized Coaxial Dynamics representative or distributor in our world-wide sales network.



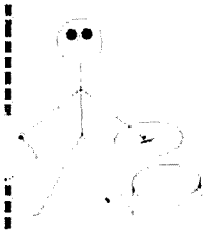
COAXIAL DYNAMICS, INC.

15210 Industrial Parkway
Cleveland, Ohio 44135
216 267 2233
1 800 COAXIAL
Telex: 98-0620

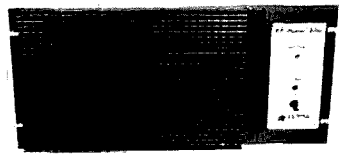
Service and Dependability...A Part of Every Product

192

THROW AWAY YOUR FALCON CATALOGS



Falcon Communications, THE source for quality, American made, MOSFET and bipolar repeater, base station and mobile power amplifiers announces a major re-design of our line.



Send for information on our models 8151, 8152, 8153, 8162, 8163, 8171, 8172, 8181, 8182, 8183, 8184, 8251, 8252, 8253, 8261, 8262, 8271, 8272 and 8282.



SEE YOU AT DAYTON

FALCON COMMUNICATIONS

P.O. Box 8979 • Newport Beach, CA 92658
(714) 760-3622

Please send all reader inquiries directly.

Multiband QRV 160-10 Emergency Pack

Field Day Winner

Fastest Antenna in the West

The Emergency Pack contains QRV 160-10 All Band kink-proof weather sealed antenna, Quick Launch kit, 70' RG-8x feedline, 160 meter adapter, all band counterpoise, 200' rotproof line. Complete and QRV. One person installs in 15 minutes.

$139.95 +$10 P.&H.

incl 47 page Tech Manual

Info: 56c s.a.s.e.

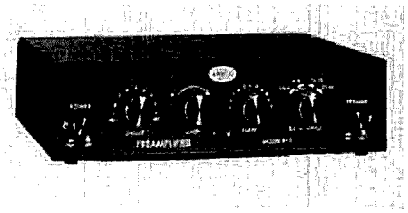
1971 N. Oak Lane 1300 E.
Provo, UT 84604-2138

AntennasWest
(801) 374-1084

135

new AMECO preamplifier

AMECO has introduced the model PT-3 Preamplifier, successor to the model PT-2. The PT-3 is a continuously tunable preamplifier that covers 1.8 through 54 MHz packaged in a cabinet with a dark-colored panel. Options are available for second receiver and separate receiving antenna capabilities.



The retail price for the PT-3 Preamplifier is $109.95; the price for the P-12T Adapter is $8.95.

For details contact AMECO, 220 E. Jericho Turnpike, Mineola, New York 11501.

Circle #305 on Reader Service Card.

advanced hf station transceiver

ICOM's new IC-781 hf base station operates on all modes and bands from 10 to 160 meters. A band spectrum scope displays signals in a 50/100/200 kHz range of your operating frequency on a multifunction 5-inch CRT screen.



The IC-781 also features:

- dual band watch
- twin passband tuning
- 99 tunable memories
- wide and narrow filters
- direct keyboard entry
- 150 watts output
- built-in power supply
- dual noise blanker
- five multifunction timers
- two internal clocks

The IC-781 comes standard with: built-in high speed automatic antenna tuner, iambic keyer, semiautomatic or full QSK CW break-in to 60 wpm, audio peaking filter, rf speech processor, multiscanning, 105-dB dynamic range receiver that continuously tunes 100 kHz to 30 MHz, plus exceptional frequency control.

For additional information contact ICOM America, Inc., 2380 116 Avenue, N.E., Bellevue, Washington 98009.

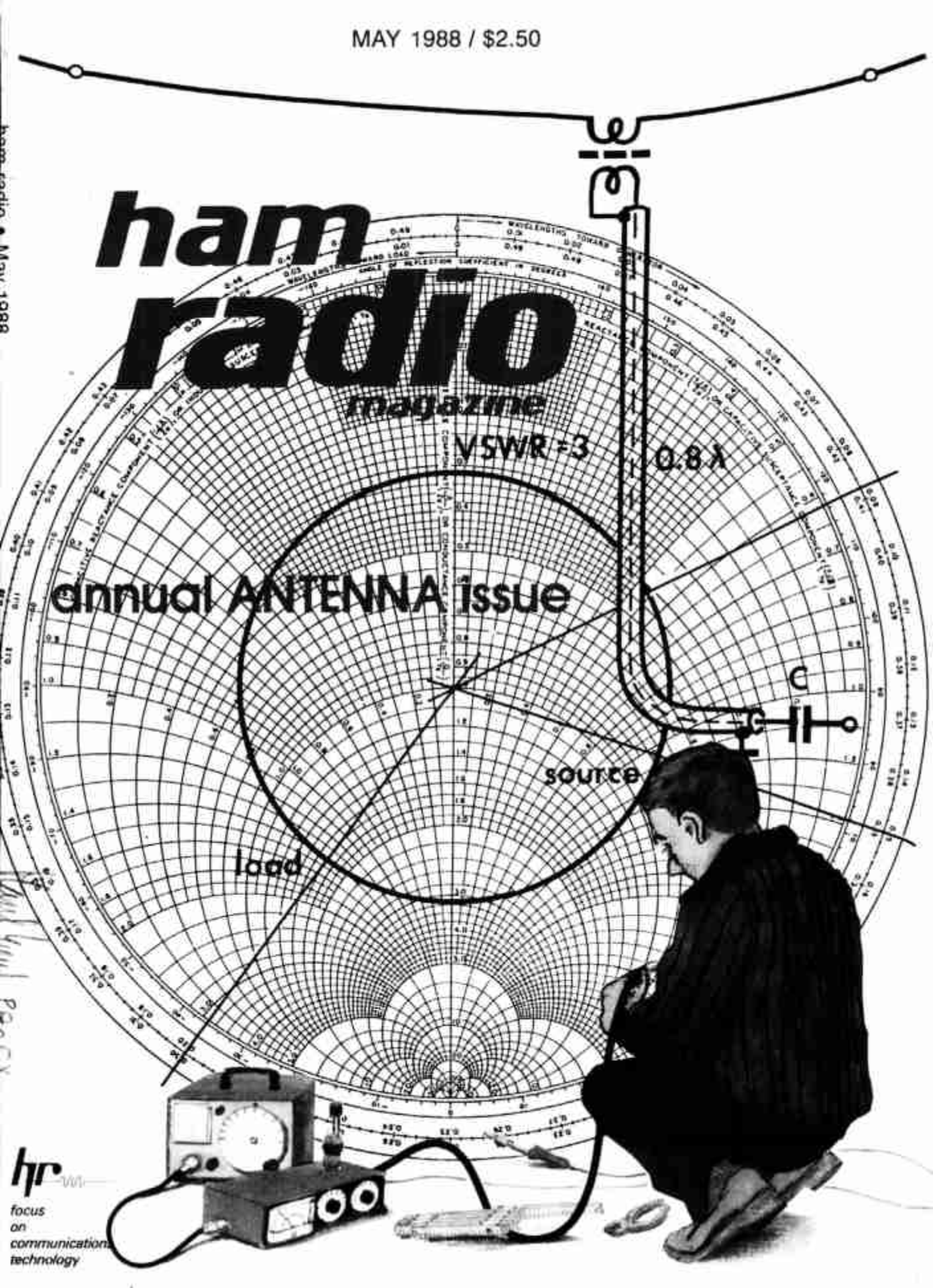
Circle #304 on Reader Service Card.

MAY 1988 / $2.50

ham radio

magazine

annual ANTENNA issue



hr

focus on communications technology

ham radio magazine

MAY 1988

volume 21, number 5

T. H. Tenney, Jr., W1NLB
publisher
and editor-in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
production editor

Peggy Tenney, KA1QDG
copy editor

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Rally Dennis, KA1JWF
director of advertising sales

Henry S. Gallup
advertising sales manager

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Teresa Leger
bookstore manager

Phil Alix, KA1IDP
traffic manager

Hans Evers, PA0CX
cover

ham radio magazine is published monthly by Communications Technology, Inc. Greenville, New Hampshire 03048-0498 Telephone 603 878 1441

subscription rates

United States
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via K) Mail mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail)
one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 101

Microfilm copies are available from University Microfilms, International Ann Arbor, Michigan 48106 Order publication number 3076

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1988 by Communications Technology, Inc. Title registered at U.S. Patent Office

Second class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *ham radio* Greenville, New Hampshire 03048-0498

contents

9 the W8JK antenna for 40, 30 and 20 meters
Ralph Fowler, N6YC

26 pathfinder: improved minimuf program
Ron Todd, K3FR

36 ham radio techniques: why not a two-element Yagi
Bill Orr, W6SAI

43 the Quad antenna: part 1 general concepts
R.P. Haviland, W4MB

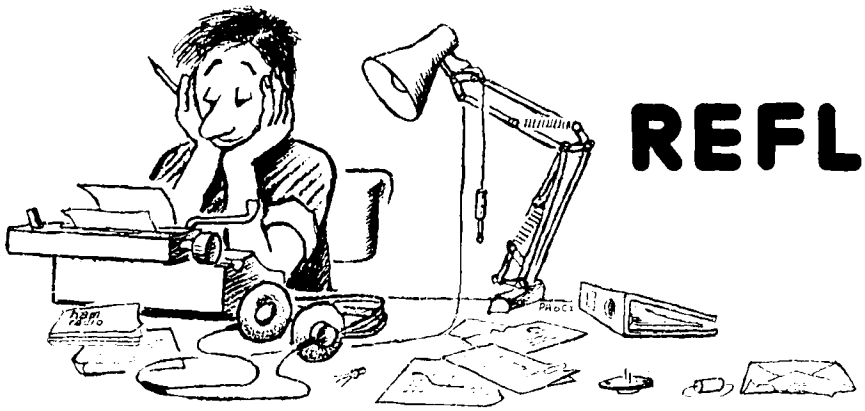
60 practically speaking: feedback
Joe Carr, K4IPV

74 a shortened 40-meter four-element sloping dipole array
Jurgen A. Weigl, OE5CWL

80 VHF/UHF world: power splitters and summers
Joe Reisert, W1JR

102 Elmer's notebook: antenna tuner
Tom McMullen, W1SL

106 advertisers index
6 comments
92 DX forecaster
98 flea market
100 ham mart
58 ham notebook
96 new products
106 reader service
4 reflections
57, 59 short circuits



REFLECTIONS

changes

Like the regeneration and change that come every spring, *ham radio* is feeling the first stirrings of new life.

Over the long winter months we've been listening to you. Your comments in letters to the editor, phone conversations, and on the bands, have been carefully gathered and mulled over by those of us who bring you the magazine *you* want to read.

Our readers are as varied as Amateur Radio itself. There are the Novices, just learning the language and venturing to build that first rig. There are the old-timers with many hours on the air and tons of experience putting together special homebrew projects. Some of you have highly technical backgrounds and want to know all the theory behind everything you undertake. Others — into Amateur Radio just for the fun of it — simply want to build something that works.

A lot of you say *ham radio* is just the magazine you're looking for. Many readers are hooked on the new technology and, with the articles offered in *HR*, are busy devising new setups. Others lament the proliferation of digital articles, and are nostalgic for the days when computers were big machines that took up entire buildings and certainly wouldn't fit in the ham shack!

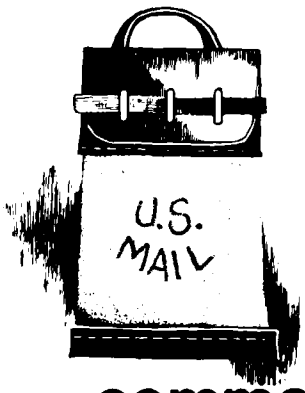
This magazine is for *you* and we need *your* help to keep it that way. Write to me or our technical editors, Marty, NB1H, or Bob, WA1TKH. Let us know what types of articles you'd like to see more of and what you could do without. You can help us shape the magazine.

You say you want solid technical material and projects, projects, projects! Why not help us out? Write something up about that gizmo you just built and send it in. It's great to see your idea in print, and you get paid for your efforts!

Don't know how to put it on paper? Send for our Authors' Guide, which gives tips on how to write for *ham radio*. If you're going to Dayton, stop by our booth. Or catch me at the Writer's Forum; I'll be there and will be happy to answer any questions.

All of us are more than willing to work with you to make *ham radio* the finest Amateur magazine. Your ideas, suggestions, and articles are all welcome. Drop us a line or call and say hello. We're waiting to hear from you.

Terry Northup
Managing Editor



comments

remarks on television series

Dear HR:

There are several points in "the technology of television part 1: historical aspects," December 1987, which are inaccurate. The reference to 60 fields and 15.750 horizontal frequency is rounded and not precise. The reason for 60-Hz vertical rate is also not precise. The use of a satellite signal (network or otherwise) to establish frequency accuracy is not good engineering practice.

Sixty hertz (at the time cycles per second) was established because in the early days of black and white television it was a simple matter to line lock the vertical sweep oscillator to the ac mains. The human eye had become accustomed to the 60-Hz flicker; the 60-Hz flicker of the TV would be "in sync" with the light flicker and not be noticed. Interlace scanning was developed because the persistence of early phosphors was such that with non-interlace 30-Hz vertical rate the picture had a noticeable fade-out following the beam trace, much like a modern scope on slow sweep or early P7 SSTV monitors. To improve on this, the scan was changed to 60 Hz and the vertical scanning was interlaced to minimize the effect of phosphor persistence fading.

The current NTSC scanning rates are not 60/15750 but 59.95 and 15,734. When color was introduced it was desirable that the color system be compatible with existing black and white receivers. As developed, the color sub carrier is a multiple of the horizontal rate so that the sidebands interleve in the rf spectrum. The small adjustment in scanning rates from 60 to 59.94 and from 15,750 to 15,734 was done in order to provide close compatibility between color and black and white signals, so that the TV sets would still work without adjustment. England had more difficulties because they went from a 405 line B&W signal to a 625 line color signal. Intermediate sets had large switching systems to go between the different scanning rates. Fortunately, the 405 line system was largely on VHF channels and the new color system was on UHF channels.

The use of a satellite signal as frequency is not good practice. It is better to use a good stable sync generator. Modern units can remain accurate to within one cycle per month at the color carrier frequency of 3.579545 MHz. A cesium or rhubidium standard was used at the network level mainly because of reliance on very early vintage sync generators which did not have this inherent stability. Current network standards allow the use of modern sync gens without atomic reference oscillators. The satellite signal is not rock stable. There are doppler shifts caused by the routine firing of stability jets which keep the satellite stable (or fixed) at a particular orbital parking spot. However, there is always some wandering because of the gravitational influences of the moon, sun, etc., which prevent the "geo-stationary" satellite from being perfectly stable. If the source switches are non-synchronous, so is your gen-lock. Few network stations would take the chance of having a sync-gen relock during a local program, commercial, or news, so this practice is not encouraged. The networks do not make 100 percent in-sync switches and do not feel obliged to do so.

As an engineer with 22 years experience in broadcasting I found these and similar errors throughout the article. While as an ATVer I am gratified that any magazine is willing to devote some space to television technology, I would have preferred that it had been edited by a person who was also familiar with the subject so that these errors would have been found, since articles are used as reference in conversations, QSOs, etc.

I have found your magazine to be excellent in technical matters but this is one area where there should have been some reference checks.

Henry B. Ruh, KB9FØ
former editor A5 Magazine.

battery storage

Dear HR:

I wish to comment on "A Battery-backed Master Power System," which appeared in your January 1988 issue.

The statement advising "...don't place the battery on a cement surface; the calcium in the floor will cause the battery to die!" is utter nonsense!

The facts are that the battery doesn't care where it's placed, but a shallow plastic pan placed under the battery is nice in case of acid spills! A new automotive battery has been sitting on my garage floor (without a pan) for over a year, and is still very much alive. A timer allows a trickle charge of about 75 mA for four hours daily. Such a system seems able to maintain a typical battery in "suspended animation" for a very long time. A duration of eight years has been verified with the test battery showing no measurable degradation.

Batteries placed on concrete floors and allowed to stand idle (no charging) have been monitored for long periods of time using continuous chart recorders. The degradation is identical with batteries placed anywhere else — slow self-discharge, depending on previous battery history and storage temperature. Some sulphation should be expected in about six months.

R.E. Elmore, W5JHJ
South Tulsa, Oklahoma 74145

the W8JK antenna
for 40, 30 and 20 meters

Face lift for an old friend using unconventional construction and feeding techniques

Here's a 40/30/20-meter antenna for both the experimenter who likes to tinker with unusual wire antennas and the seasoned Amateur looking for low-band operation equivalent to a three-element Yagi at elevations below one-half wavelength. Its odd appearance has raised quite a few eyebrows at my location. Performance has been more than satisfactory and it was pure fun to build.

The W8JK is a close-spaced array, constructed as two coplanar dipoles less than one-quarter wavelength apart and driven (usually) 180 degrees out of phase. It can be configured as a two-element array with each dipole approximately one-half wavelength long, or as a four-element array with each dipole approximately one wavelength long as in **fig. 1**. By making each dipole approximately one-half wavelength long on 40 meters with one-eighth wavelength spacing, the system operates as a two-element array on 40 meters with around 4.2 dB gain, and as a four-element array on 20 meters with about 5.7 dB gain. Spacing and phase difference cause the fields of the two elements to be subtractive and cancel in all directions except along the array axis. In this direction they produce the well-known figure-eight pattern. For a detailed discussion of close-spaced beams like the W8JK, see reference 1. The theory has already been well developed; this article is aimed at the practical details of construction and feeding.

dimensional considerations

Figure 2 shows how I built my version of the W8JK. A dipole length of 59 feet and spacing of 16 feet were chosen for operation on 40 and 20 meters. These dimensions were a compromise between construction considerations (a 90-foot distance between my two pine tree end supports) and theoretically recommended element lengths. Actually, any length between 1.25 wavelengths and slightly less than one-half wavelength will work without significantly affecting the characteristics of this antenna. This gives a dimensional range between 83 feet, 1.25 wavelengths on 20 meters, and 66 feet, one-half wavelength on 40 meters. There is no advantage in cutting element lengths for resonance in the 40-meter band because the VSWR remains very high, and tuned feeders and/or a tuning network will be required in either case. All feedline lengths and resonant frequencies discussed in this article are based on 59-foot antenna element lengths. Changing element lengths changes the feedline lengths required, but the same principles apply.

I recommend using 12-foot bridle arms with the bridles spaced close to the antenna supports as shown in **fig. 2**. Adjust the element lengths within the above limits. These adjustments don't affect operation or match, since this antenna is operated as a nonresonant one and uses tuned feeder lengths — this will make the impedance at the feeder input purely resistive. If length A in **fig. 2** is excessive, midpoint sag will quickly increase (unless tension is increased), and antenna height will decrease. If the bridle arms are significantly less than 12 feet, the bending moment on the 2 by 4 inch bridle supports will increase dramatically, causing them to break under the necessary 100-pound tension. Unacceptable antenna droop occurs with less than 100 pounds of tension. There is considerable interaction between the tension, bridle arm length, midpoint sag and loads on the bridle support. Keep this in mind if you must adjust the dimensions to accomodate your supports. If you use the dimensions shown in **fig. 2** and 100-pound counterweights, midpoint sag will be about 6 feet.

construction

Antenna construction is complicated, as compared with a dipole or Vee, by the need to feed both elements 180 degrees out of phase. Keep the elements relatively coplanar and maintain spacing between the wires. Do this by using bridles at each end of the antenna and a lightweight support at the midpoint.

The end bridle assemblies are made of lightweight fir or pine two-by-fours 16 feet long. I first tried making a truss assembly with PVC, but the design required to give it rigidity became complicated and the weight soon exceeded that of a simple wooden member.

By Ralph Fowler, N6YC, Route 1, Box 253R, Pearl River, Louisiana 70452

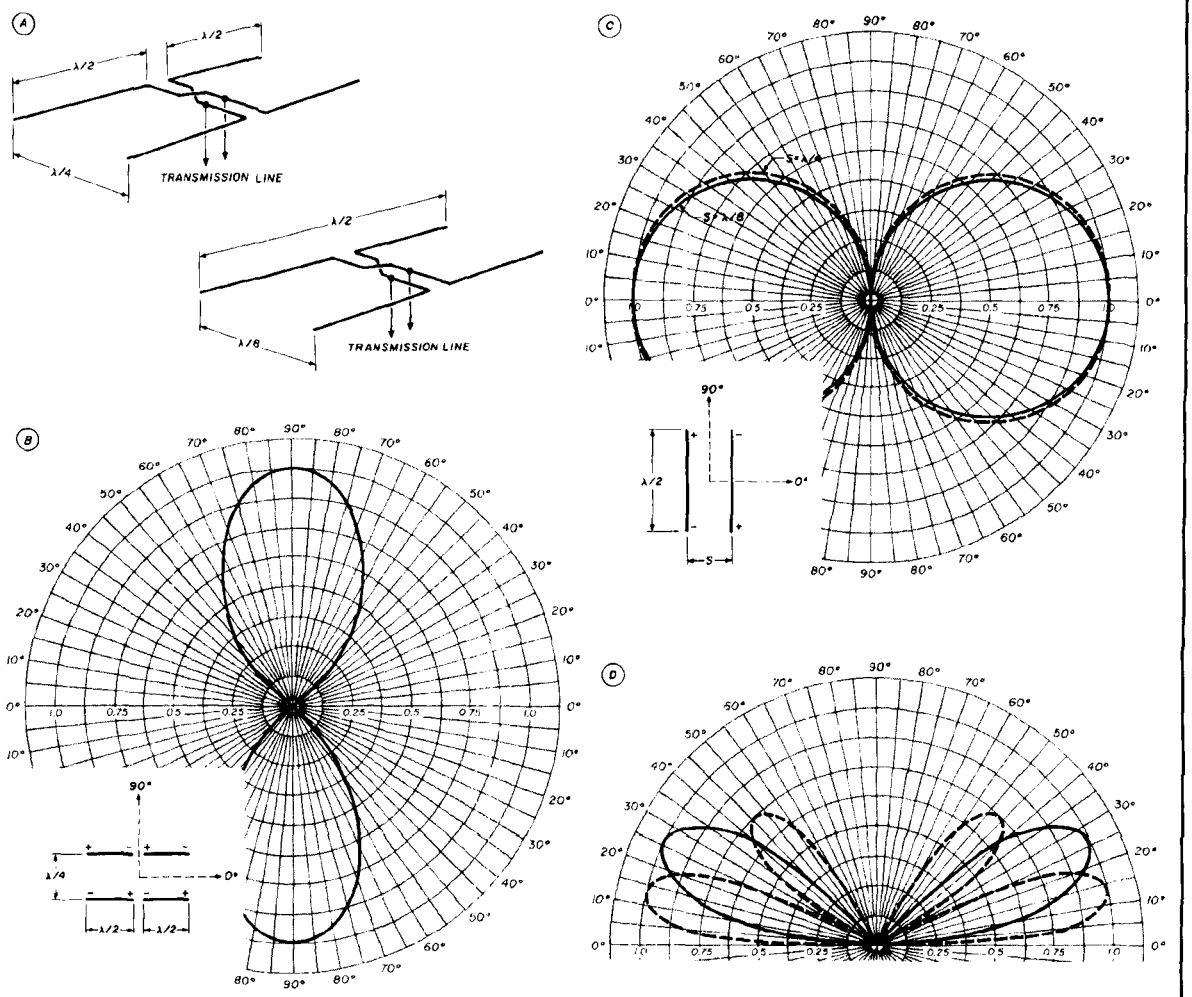


fig. 1. Two- and four-element W8JK. (A) Shows two- and four-element arrays, (B) is a free space directive diagram of a four-element array, (C) is a free space directive diagram of a two-element array, (D) is the vertical pattern of a two- and four-element array. Solid curve, height 1/2 wavelength; broken curve, height 1 wavelength.

Choose your lumber carefully and pick a lightweight, knot-free, sap-free piece. (You'd be surprised how the weight varies.) Weatherproof by applying two coats of spar varnish. Drill 1/4-inch holes near the ends to route the 1/4-inch polypropylene rope. Poly rope really isn't the best because it eventually deteriorates when exposed to sunlight. I have had good luck with mine over the past 14 months, but a better choice is the antenna rope advertised in ham magazines.

The center support is made of thinwall 2-1/2 inch PVC pipe as shown in **fig. 2**. It supports the phasing lines and maintains element spacing. Keep the wide spacing of the phasing lines; it serves a useful function. My Smith chart analysis of the phase line impedance transfer shows that the higher the impedance of this portion of the feedline (it is part of the feedline system), the closer the transferred impedance at the input end of the feedline will be to 50 ohms on 20 meters.

Use poly rope to truss the center support assembly and keep it from bending. The phasing lines are made from No. 12 wire; they pass through wire ties which attach to 2-inch ceramic standoffs. (You can use Plexiglas™ here but PVC is not recommended.) I attached the 450-ohm ladder line to the PVC with tape; this hasn't been a problem at 100 watts output. With higher power, especially on 20 meters, the high feedpoint resistance and VSWR create high rf voltages, so it may be necessary to use good quality standoffs here. PVC does not tolerate high rf voltages very well.

Because the end supports and antenna will sway in the wind, you must allow for some movement.

Attach 100-pound counterweights to the ends with a pulley arrangement (see fig.2). I believe that two weights are better than one; in high winds the range of motion is divided equally between the two counterweights, and the resultant peak tension presented to the wires and end insulators is decreased.

Antenna insulators are lightweight 2-1/2 by 12-inch pieces of 1/2-inch thick Plexiglas, with 1/4-inch holes carefully drilled and chamfered to minimize point loading, stress cracking, and failure.

Pulleys should be the best you can afford and are, in my opinion, the weakest part of the system. Those used in marine applications, though expensive, are probably the best. I chose the common metal hardware store variety, approximately 4 by 3 inches, for $6 each. So far they haven't failed even though the antenna has been subjected to the sway of tall pines in 60-mph winds.

I used No. 12 gauge stranded Copperweld™ (don't use ordinary softdrawn wire as it will stretch) for the elements. You must use a large-gauge wire because the antenna currents are relatively high as a consequence of the low radiation resistance. Losses in the wire can become considerable with small-gauge wire. The efficiency of my antenna with respect to copper losses is about 90 percent.

feeding the antenna

Before discussing antenna impedances, it is important to distinguish between the array feedpoint impedance (defined at the point where the 450-ohm ladder line connects to the phasing line) and the terminal impedance (at the ends of the elements where the phasing lines connect). Feedline input impedance is just that — the impedance at the transmitter end of the feedline.

This antenna's feedpoint impedance is low when operated at its fundamental half-wavelength frequency. At 7.15 MHz, I calculated approximately 11 + j13 ohms based on calculator rotation of measurements made at the input of the feedline. It is higher at 14.15 MHz (the higher 1.25-wavelength frequency range) — about 106 – j578 ohms according to similar calculations. Because neither value will match common feedline impedances, a high VSWR will exist and open-wire feeder, such as 450-ohm ladder line, is suggested (despite its reputation as a "fair weather feedline") to minimize VSWR losses. Although other types of balanced feedline can be used, 450-ohm ladder line handles a kilowatt and has the benefit of having a Z_0 that is useful as an impedance transformer on 20 meters.

For those who choose other feedlines, fig. 3 shows an approximate Smith chart representation (chart Z_0 is 385 ohms) of the impedance of this antenna (with 59-foot elements) at the antenna feedpoint (points B

coaxial R. F. antenna switches

Heavy Duty switch for true 1 Kw POWER – 2 Kw P.E.P.
Ceramic with Coin Silver Switch Contacts

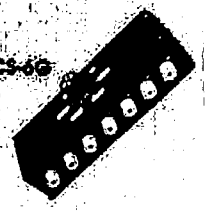
#CS-3G



Single Pole, 3 Position.
Desk or wall mount
All unused positions grounded

#CS-3G – UHF connectors / $36.50*
#CS-3G-BNC – BNC connectors / $43.95*

#CS-6G



Single Pole, 5 Position.
All unused positions grounded

#CS-6G – UHF connectors / $46.50*
#CS-6G-BNC – BNC connectors / $59.50*

*Shipping and handling for any item add $2 each.

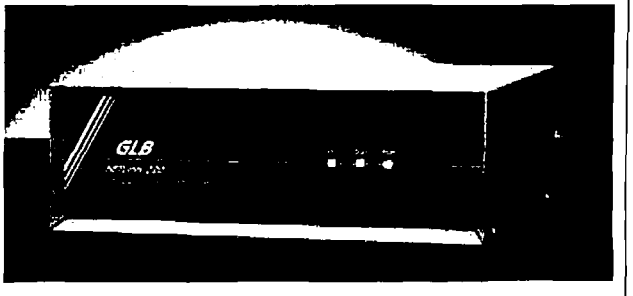
ALL OUR PRODUCTS MADE IN USA
BARKER & WILLIAMSON
Quality Communication Products Since 1932
At your Distributors write or call
10 Canal Street, Bristol PA 19007
(215) 788-5581

NEW FROM GLB

GLB NETLINK 220
HIGH-SPEED DATA TRANSCEIVER

GLB Electronics is pleased to announce a fast digital vs. digital voice data radio intended to further the development of the international amateur packet network.

Netlink radios are specifically intended for use in private, unattended applications requiring long term service. Compatible with any digital format they turn around transmit to receive and receive to transmit in less than a millisecond while holding keying transients within the channel. A digital sampling AFC tracks transmitted signal vs frequency to maintain low error rates over long periods of time. In addition they utilize crystal ovens and temperature-compensated circuitry for reliable operation at unheated sites.



FEATURES
Conservative design
Data transparent operation
Digital sampling AFC
Optional receive hard mod
High speed squelch (approx. 0.1 ms)
Power conserving operation
PTT (DCD) & PWR LEDs
Rx decode antenna switch (+)
Transmitter timeout timer
Compatible with TNC2 controllers
Complies with all applicable Sections of Part 15 FCC Rules

SPECIFICATIONS
Data rate: 19,200 baud
Data format: any format incl. NRZ and NRZI
Modulation: FSK
Signal rate: 57.6 or 153.6 kHz
Frequency: 220 – 225 MHz
Rx bandwidth: 30 kHz
Turnaround time: 1 ms Tx to Rx
1 ms Rx to Tx
Power output: 2 Watts
Fuse: 3 Amp
Digital sensitivity: 5 uv for 1 error/K
Squelch response time: 1 ms
Speaker output: 600 ohms max
Power: 12 VDC
Operating temperature range: 10 to 120 degrees F
Antenna connector: BNC
RS232 connector: DB25S
Dimensions: 12 x 10 x 3 in
Weight: 5 lbs. 8 oz.

Request our FREE catalog
Contact GLB for additional information and pricing on:
Amateur packet radio products, private network radios, repeaters, CW/DVR & controllers for amateur & commercial use

See us at DAYTON Booth 318

Amateur net $ 699.95
List price $ 799.95

GLB ELECTRONICS, INC.
151 Commerce Pkwy., Buffalo, NY 14224
716 675 6740 9 to 4

178

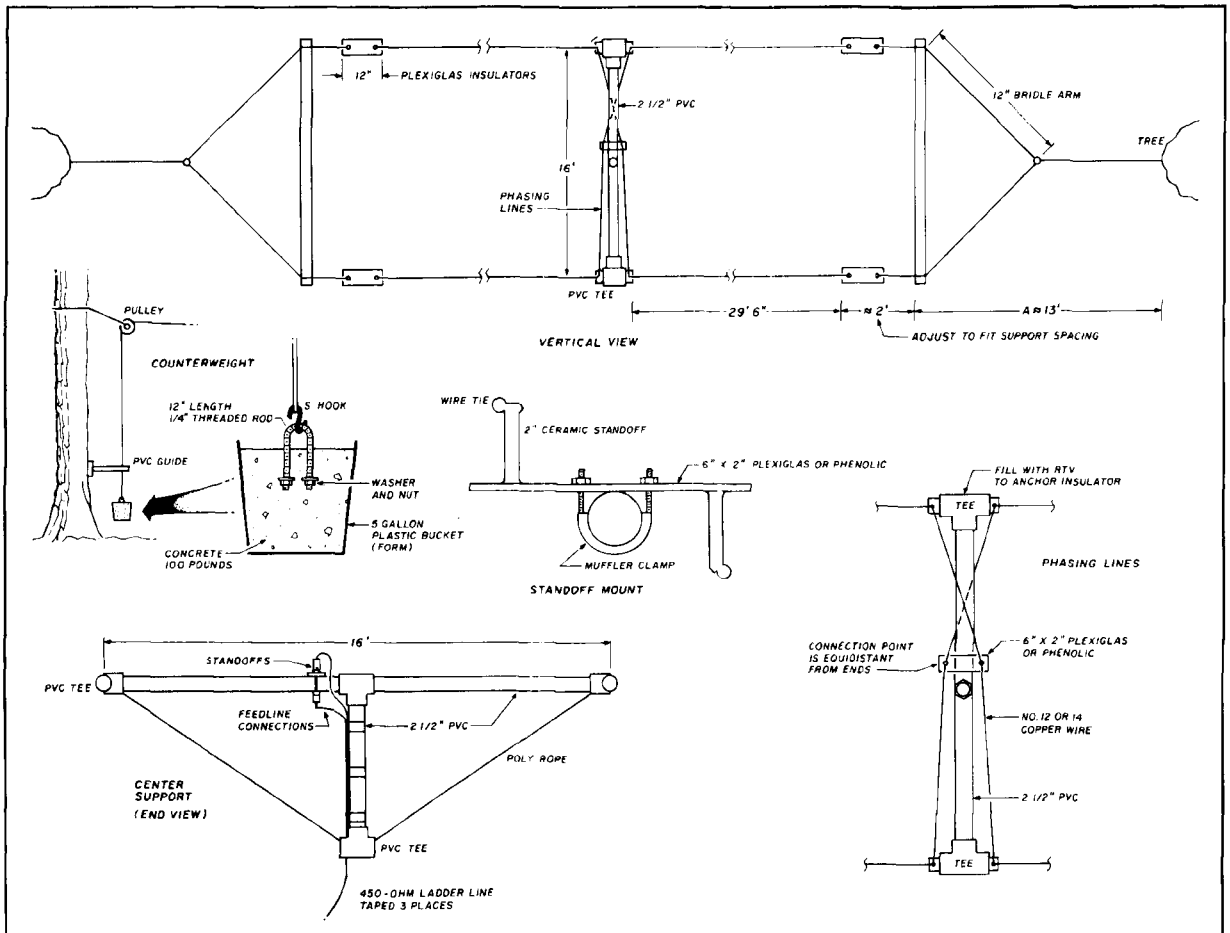


fig. 2. W8JK construction.

and C on the chart). The chart was constructed with data gathered with my collection of homebrew test equipment and "calculator rotated" to get at the feedpoint impedance. As such, it is approximate and useful as a guide for feedline length determination. These impedances can also be transformed on the **fig. 3** Smith chart or calculator rotated back along the 8.2 feet of phasing lines to the antenna terminals themselves. Using $V_f = 0.97$ and $Z_o = 400$ ohms (estimated values) for the phasing line, antenna impedance turns out to be approximately 11 ohms at 7.93 MHz* and approximately 5000 ohms at 15.86 MHz, the dipole resonant frequencies. These terminal impedance values appear to be within experimental tolerances of the theoretical values. They are approximate due to the difficulty in

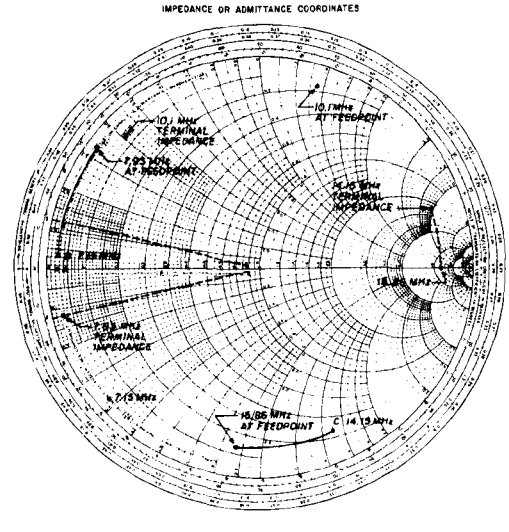


fig. 3. Feedpoint and terminal impedances of W8JK. Z_0 = 385 ohms.

*The calculated radiation resistance of the array, approximately 11 ohms, is significantly higher than the theoretical value, near 4 ohms. This is likely because of the higher radiation resistance of the dipoles (estimated near 90 ohms), which are only 0.3 wavelengths above ground at 7.93 MHz. In any case, the increased resistance is beneficial. Residual reactance at 7.93 MHz, the dipole resonant frequency, is probably a result of slight mistuning between the elements and mutual reactance.

1988 CALLBOOKS



The "Flying Horse" sets the standards

Continuing a 67 year tradition, we bring you three new Callbooks for 1988.

The North American Callbook lists the calls, names, and address information for 478,000 licensed radio amateurs in all countries of North America, from Canada to Panama including Greenland, Bermuda, and the Caribbean islands plus Hawaii and the U.S. possessions.

The International Callbook lists 481,000 licensed radio amateurs in countries outside North America. Its coverage includes South America, Europe, Africa, Asia, and the Pacific area (exclusive of Hawaii and the U.S. possessions).

The 1988 Callbook Supplement is a new idea in Callbook updates, listing the activity in both the North American and International Callbooks. Published June 1, 1988, this Supplement will include thousands of new licenses, address changes, and call sign changes for the preceding 6 months.

The 1988 Callbooks will be published December 1, 1987. See your dealer or order now directly from the publisher.

☐ North American Callbook
incl. shipping within USA $28.00
incl. shipping to foreign countries 30.00

☐ International Callbook
incl. shipping within USA $30.00
incl. shipping to foreign countries 32.00

☐ Callbook Supplement, published June 1st
incl. shipping within USA $13.00
incl. shipping to foreign countries 14.00

SPECIAL OFFER

☐ Both N.A. & International Callbooks
incl. shipping within USA $55.00
incl. shipping to foreign countries 60.00

• • • • • • • • • • • •

Illinois residents please add 6½% tax.
All payments must be in U.S. funds.

RADIO AMATEUR **callbook** INC.
Dept. F
925 Sherwood Dr., Box 247
Lake Bluff, IL 60044, USA

Tel: (312) 234-6600 VISA

fig. 4. BASIC listing of program for impedance "rotation" calculations.

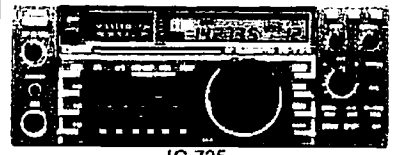
```
10 REM THIS PROGRAM CONVERTS IMPEDANCES, R(P)/C(P) TO/FROM R(S)+JX(S),
   TRANSFORMS
20 REM THEM ALONG A TRANSMISSION LINE TO THE ANTENNA OR GENERATOR,
   AND COMPUTES
30 REM SWR, RETURN LOSS AND REFLECTION COEFFICIENT.
40 REM
50 PRINT CHR$(147):PRINT:PRINT
60 PRINT "1. CONVERT R(P)/C(P) TO R(S)+jX(S)":PRINT
70 PRINT "2. CONVERT R(S)+jX(S) TO R(P)/C(P)":PRINT
80 PRINT "3. COMPUTE SWR, RETURN LOSS AND REF. COEFF.":PRINT
90 PRINT "4. TRANSFORM R(S)+jX(S) TO ANTENNA":PRINT
100 PRINT "5. TRANSFORM R(S)+jX(S) TO GENERATOR":PRINT:PRINT:PRINT
110 INPUT"CHOOSE OPTION....";OPT
120 PRINT CHR$(147):OPT$=""
130 ON OPT GOTO 180,390,580,780,1050
140 GOTO 50
150 REM
160 REM
170 REM
180 REM THIS ROUTINE CONVERTS R(P)/C(P) FROM A PARALLEL TYPE NOISE BRIDGE
190 REM TO Z=R(S)+JX(S). ENTER CAP. VALUES AS "-", IND. VALUES AS "+".
200 REM
210 PRINT CHR$(147)
220 INPUT"INPUT R(P)";RP
230 INPUT"INPUT C(P) IN PF (CAP NEGATIVE)";CP
240 INPUT"INPUT FREQ IN MHZ";FR:FM=FR*1E+06
250 XP=1/(2*π*FM*CP*1E-12)
260 RS=RP/(1+(RP/XP)↑2)
270 XS=RS*RP/XP
280 XS=(INT(100*XS))/100:RS=(INT(RS*100))/100
290 INPUT"EXTENDER USED ?";OPT$
300 IF OPT$="Y" THEN RS=RS-100
310 PRINT:PRINT:PRINT
320 IF XS>=0 THEN PRINT "Z=";RS;"+J";XS
330 IF XS<0 THEN PRINT "Z=";RS;"-J";-XS
340 PRINT:PRINT:OPT$=""
350 PRINT"PRESS 'RETURN' TO RESTART -"
360 INPUT"ANY OTHER KEY TO REPEAT";OPT$
370 IF OPT$="" THEN PRINT CHR$(147):GOTO 50
380 GOTO 180
390 REM
400 REM THIS ROUTINE CONVERTS Z=R(S)+JX(S) TO R(P)/C(P)
410 REM
420 PRINT CHR$(147)
430 INPUT"INPUT R(S)";RS
440 INPUT"INPUT X(S)";XS
450 INPUT"INPUT FREQ (MHZ)";FR:FM=FR*1E+06
460 RP=(RS↑2+XS↑2)/RS:XP=(RS↑2+XS↑2)/XS:CP=1E+12/(2*π*FM*XP)
470 RP=(INT(100*RP))/100:CP=(INT(100*CP))/100:PRINT:PRINT:PRINT
480 IF CP>=0 GOTO 500
490 PRINT"R(P)=";RP;"OHMS","C(P)=";CP;"PF (CAP)":PRINT:PRINT:GOTO 510
500 PRINT"R(P)=";RP;"OHMS","C(P)=";CP;"PF (IND)":PRINT:PRINT
510 OPT$=""
520 PRINT"PRESS 'RETURN' TO RESTART -"
530 INPUT"ANY OTHER KEY TO REPEAT";OPT$
540 IF OPT$="" THEN PRINT CHR$(147):GOTO 50
550 PRINT CHR$(147):GOTO 390
560 REM
570 REM
580 REM THIS ROUTINE CALCULATES SWR, REF. COEFF. AND RETURN LOSS
590 REM
600 PRINT CHR$(147)
610 INPUT"INPUT ZO OF LINE";ZO
620 INPUT"INPUT R(S)";RS
```

```
630 INPUT"INPUT X(S)";XS
640 RO=SQR(((RS-ZO)©2+XS©2)/((RS+ZO)©2+XS©2))
650 RL=-20*LOG(RO)/LOG(10):SWR=(1+RO)/(1-RO)
660 RO=(INT(100*RO))/100:RL=(INT(100*RL))/100:SWR=(INT(100*SWR))/100
670 PRINT:PRINT:PRINT:OPT$=""
680 PRINT"REF. COEFF =";RO:PRINT
690 PRINT"RETURN LOSS =";RL;"dB":PRINT
700 PRINT"SWR =";SWR
710 PRINT:PRINT
720 PRINT"PRESS 'RETURN' TO RESTART -"
730 INPUT"ANY OTHER KEY TO REPEAT";OPT$
740 IF OPT$="" THEN PRINT CHR$(147):GOTO 50
750 PRINT CHR$(147):GOTO 580
760 REM
770 REM
780 REM THIS ROUTINE TRANSLATES R(S)+jX(S) TO THE ANTENNA (LOAD)
790 REM
800 PRINT CHR$(147)
810 INPUT"INPUT R(S)";RS
820 INPUT"INPUT X(S)";XS
830 INPUT"INPUT ZO";ZO
840 INPUT"INPUT LINE LENGTH (FT)";FT
850 INPUT"INPUT FREQ (MHZ)";FR:FM=FR*1E+06
860 INPUT"INPUT V(F) OF LINE (.XX)";VF
870 INPUT"INPUT LINE LOSS IN dB/100 FT.";DB:A=DB*FT/(100*8.686)
880 HW=.5*984*VF/FR: B=FT*π/HW
890 D=EXP(4*A)+1+2*EXP(2*A)*COS(2*B)
900 RB=(EXP(4*A)-1)/D:XB=(2*EXP(2*A)*SIN(2*B))/D
910 ALPHA=RS-RB*ZO:BETA=XS-ZO*XB:GAMMA=ZO-RS*RB+XS*XB:DELTA=RB*XS+RS*XB
920 RL=(ALPHA*GAMMA-BETA*DELTA)*ZO/(GAMMA©2+DELTA©2)
930 XL=(GAMMA*BETA+ALPHA*DELTA)*ZO/(GAMMA©2+DELTA©2)
940 PRINT:PRINT:PRINT:OPT$=""
950 RL=(INT(100*RL))/100:XL=(INT(100*XL))/100
960 IF XL>=0 THEN PRINT"Z(ANT)=";RL;"+J";XL:GOTO 980
970 IF XL<0 THEN PRINT "Z(ANT)=";RL;"-J";-XL
980 PRINT:PRINT
990 PRINT"PRESS 'RETURN' TO RESTART -"
1000 INPUT"ANY OTHER KEY TO REPEAT";OPT$
1010 IF OPT$="" THEN PRINT CHR$(147):GOTO 50
1020 PRINT CHR$(147):GOTO 780
1030 REM
1040 REM
1050 REM THIS ROUTINE TRANSLATES R(S) +JX(S) TO THE GENERATOR (SOURCE)
1060 REM
1070 REM
1080 PRINT CHR$(147)
1090 INPUT"INPUT R(S)";RS
1100 INPUT"INPUT X(S)";XS
1110 INPUT"INPUT ZO";ZO
1120 INPUT"INPUT LINE LENGTH (FT)";FT
1130 INPUT"INPUT FREQ (MHZ)";FR:FM=FR*1E+06
1140 INPUT"INPUT V(F) OF LINE (.XX)";VF
1150 INPUT"INPUT LINE LOSS IN DB/100 FT.";DB:A=DB*FT/(100*8.686)
1160 HW=.5*984*VF/FR:B=FT*π/HW
1170 D=EXP(4*A)+1+2*EXP(2*A)*COS(2*B)
1180 RB=(EXP(4*A)-1)/D:XB=(2*EXP(2*A)*SIN(2*B))/D
1190 ALPHA=RS+RB*ZO:BETA=XS+ZO*XB:GAMMA=ZO+RS*RB-XS*XB:DELTA=RB*XS+RS*XB
1200 RG=(ALPHA*GAMMA+BETA*DELTA)*ZO/(GAMMA©2+DELTA©2)
1210 XG=(GAMMA*BETA-ALPHA*DELTA)*ZO/(GAMMA©2+DELTA©2)
1220 RG=(INT(RG*100))/100:XG=(INT(100*XG))/100
1230 PRINT:PRINT:PRINT
1240 IF XG>=0 THEN PRINT"Z(GEN)=";RG;"+J";XG:GOTO 1260
1250 IF XG<0 THEN PRINT"Z(GEN)=";RG;"-J";-XG
1260 PRINT:PRINT:OPT$=""
1270 PRINT"PRESS 'RETURN' TO RESTART -"
1280 INPUT"ANY OTHER KEY TO REPEAT";OPT$
1290 IF OPT$="" THEN PRINT CHR$(147):GOTO 50
1300 PRINT CHR$(147):GOTO 1050
1310 END
```

THIS PROGRAM WAS WRITTEN IN C-64 BASIC. NOTE, HOWEVER, THAT "©" IN THE LISTING MEANS "EXPONENTIATION", i.e. 5©2=25.

800-882-1343

ICOM



IC-735

HF Equipment	List	JUN's
ICOM		
IC-781 New Deluxe HF Rig	$5995	Call $
IC-761 Loaded with Extras	2899	Call $
IC-735 Gen. Cvg Xcvr	1099	Call $
IC-751A Gen. Cvg Xcvr	1699	Call $
Receivers		
IC-R7000 25-1300* MHz Rcvr	1199	Call $
IC-R71A 100 kHz-30 MHz Rcvr	999	Call $
VHF		
IC-28A/H FM Mobile 25w/45w	469/499	Call $
IC-02AT FM HT	409.95	Call $
IC-u2AT Micro HT	329	Call $
IC-900 Six Band Mobile	839	Call $
UHF		
IC-48A FM Mobile 25w	509	Call $
IC-04AT FM HT	449	Call $
IC-12AT 1.2 GHZ HT	473	Call $
220 MHz		
IC-38A 25w FM Xcvr	489	Call $
IC-37A FM Mobile 25w	499	Call $

KENWOOD

KENWOOD HF Equipment		
TS-940S/AT Gen. Cvg Xcvr	2449.95	Call $
TS-440S/AT Gen. Cvg Xcvr	1379.95	Call $
VHF		
TS-711A All Mode Base 25w	1029.95	Call $
TR-751A All Mode Mobile 25w	649.95	Call $
TM-2530A FM Mobile 25w	479.95	Call $
TM-2550A FM Mobile 45w	499.95	Call $
TM-2570A FM Mobile 70w	599.95	Call $
TH-215A 2m HT Has It All	379.95	Call $
TH-25AT 5w Pocket HT NEW	349.95	Call $
TM-721A 2m/70cm FM Mobile	649.95	Call $
UHF		
TH-415A 2.5w 440 HT	399.95	Call $
TH-45AT 5w Pocket HT NEW	369.95	Call $
220 MHz		
TM-3530A FM 220 MHz 25w	499.95	Call $
TH-31BT FM 220 MHz HT	299.95	Call $
TH-315A Full Featured 2.5w HT	399.95	Call $

YAESU

YAESU HF Equipment		
FT-747 GX New Economical Performer	889.95	Call $
FT-757 GX II Gen. Cvg Xcvr	1129.95	Call $
VHF		
FT-212RH NEW 2m 45w Mobile	459.95	Call $
FT-211RH FM Mobile 45w	389.95	Call $
FT-290R All Mode Portable	599.95	Call $
FT-23 R/TT Mini HT	344.95	Call $
FT-209RH FM Handheld 5w	389.95	Call $
VHF/UHF Full Duplex		
FT-736R, New All Mode 2m/70cm	1749.95	Call $
Dual Bander		
FT-727R 2m/70cm HT	439.95	Call $
FT-109RH New HT	399.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

183

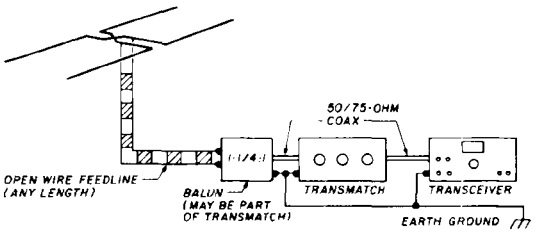


fig. 5. Matching the transmitter with a transmatch and balun.

possibility because this system presents impedances to the transmatch as high as 20,000 ohms and as low as 12 ohms, using 450-ohm feedline. Some transmatches won't match to these extreme impedances, and a ferrite balun may self-destruct with high power. One solution is to change the feedline; lengthening or shortening it by less than one-quarter wavelength should do the trick. Lengths to avoid are those approximating L = 30 + 60N feet at 7.15 MHz and 25 + 30N feet at 14.15 MHz. These will create very high impedances at the transmitter end of the feedline, are difficult to match, and bring high rf voltages into the station.

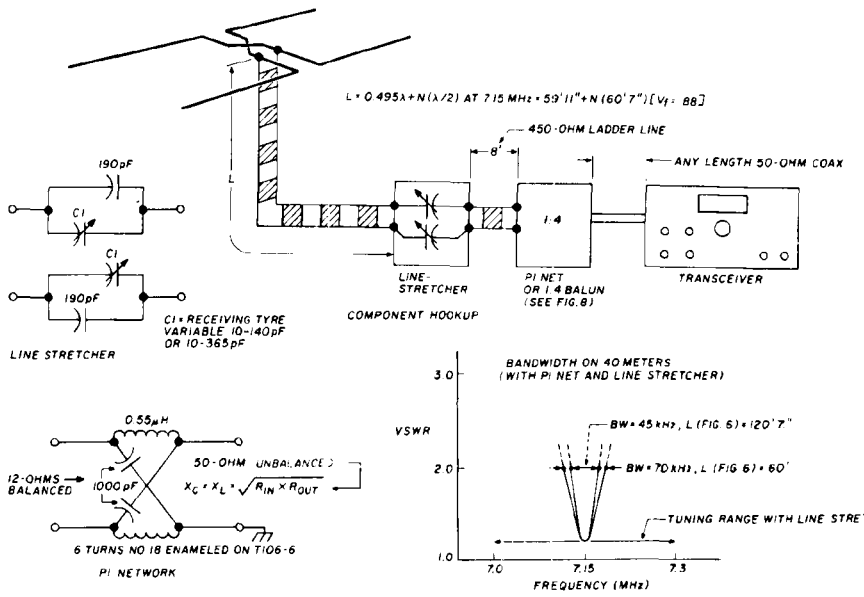


fig. 6. 40-meter configuration.

establishing a Z_0 for the phasing lines, which cross and therefore do not maintain constant separation and Z_0.

Figure 4 gives a BASIC listing of a simple program for impedance "rotation" calculations along a feedline and also calculation of VSWR, reflection coefficient, and return loss. The program accounts for losses in the line, a small but important contribution with open-wire line at 14 MHz and above.

Figure 5 shows how to match the feedline to the transmitter with a transmatch and balun. This allows unrestricted operation over the entire 20- and 40-meter bands (and anything in between). It also gives the most flexibility because you don't have to use a specified feeder length. The exception is when the feedline length you select presents an extremely high or low impedance at the input to the feedline — one which the transmatch can't handle. This is a definite

operating on 40 meters without a transmatch

This antenna can be considered a multiband antenna in that it radiates effectively on 40 and 20 meters, but the impedances on each band are very different. Without a transmatch, it requires tuned feedlines and/or matching networks, or some other impedance transformation scheme to get near 50 ohms. I took a simple approach and chose a feedline length that transformed the antenna feedpoint impedance to a low-value resistive impedance, then used a suitable network to get near 50 ohms. Since each band requires a different length of tuned feedline, a simple arrangement designed to switch a section of feedline and its associated matching network in or out from 40 to 20 meters would be effective. Because the inherent bandwidth of this antenna is rather restric-

tive on 40 meters (45 to 70 kHz at VSWR = 2), full-band operation over 7.0 to 7.3 MHz can be provided by adding a simple capacitive tuner. While the bother of changing feedline lengths when changing bands, and the narrow bandwidth on 40 may be somewhat objectionable, remember that it's hard to beat more than 4 dB gain at 7 MHz — unless you can afford the cost of three full elements and the monster tower to support it!

On 40 meters, if we feed this antenna with an integral number of half wavelengths of feedline, the impedance at the feedline input will be that at the antenna itself (approximately 12 ohms resistive at the resonant frequency). However, off resonance at 7 MHz, this antenna is capacitive (too short). But if we use the proper length feeder, we can compensate for the capacitive reactance and resonate the feeder/antenna system at 7.15 MHz. The impedance at the input to the feedline will remain near 12 ohms resistive. It's then a relatively simple matter to transform the 12 ohms close to 50 ohms with a 1:4 balun or balanced pi network. The only problem remaining is to overcome the relatively narrow bandwidth on 40 meters due to the low radiation resistance.

Figure. 6 shows the addition of a simple series capacitive tuner. I call it a line stretcher because it adds or subtracts series capacitance to each leg of the feedline, and effectively varies the feedline length by a small amount to maintain resonance (zero reactance) and allow operation over 7.0 to 7.3 MHz. Capacitors used in the line stretcher should be heavy enough to handle the current at the low-impedance level. I recommend transmitting micas or doorknobs for high power levels. Receiving-type micas, paralleled for added current capacity, should be sufficient at low (< 100 watts) power levels. Voltages are low so receiving-type variables can be used, and C_{max} can be anything in the neighborhood of 150 to 365 pF or more for an adequate tuning range. The range is essentially defined by the 190-pF capacitors. You should stay reasonably close to this value to avoid an excessively wide or narrow tuning range.

To use the line stretcher, find the length of main feedline required to make the antenna/feedline/line stretcher/pi network (or balun) combination present a near 50-ohm resistive input impedance at 7.15 MHz. Make sure that the length of feedline used to interconnect the pi network (or balun) to the line stretcher is the length that will be used in operation because it also affects the feedline input impedance. A line stretcher to pi net/balun interconnect length besides those recommended in **figs. 6** and **7** will work (assuming you prune the main feedline to accommodate them), but the tuning range will probably decrease and the VSWR will increase somewhat. The recommended lengths produce the best results.

Prune the main feedline length for lowest VSWR at the center of the band, 7.15 MHz, with the capacitor plates of the line stretcher half meshed. This should allow operation over 7.0 to 7.3 MHz, with the line stretcher capacitors adjusted equally to maintain balance. Simplify main feedline pruning by using a noise bridge connected to the transmitter side of the pi net or a VSWR meter. In the absence of these, the lengths recommended in the text will get you close, assuming you duplicate my design.

Whether you choose to use a 1:4 coax balun (balanced to unbalanced) shown in **fig. 8** or the balanced pi network shown in **fig. 6** is a matter of taste, since both perform well. The pi net is a balanced adaptation of the traditional pi network used in virtually all transmitters. Component values are dictated by the frequency of operation and transformation values. They are defined by:

$$X_1 = X_C = \sqrt{R_1 \cdot R_2} \qquad (1)$$

where R_1 is 12 ohms (40 meters) and R_2 is Z_0 of the transmitter, generally 50 ohms. Capacitance values are close to 900 pF and inductance near 0.55 μH for a 12- to 50-ohm conversion at 7.15 MHz.

As a test, I built the pi net using small postage-stamp size 1000-pF 300-volt silver micas and T106-6 toroids. With 100 watts output from my TS-830S there were barely perceptible signs of capacitors heating while operating under matched-load conditions. However, this was only an experiment. To avoid possible failure under accidental mismatch conditions, transmitting doorknob or mica types are recommended. Bandwidth of the pi net is shown in **fig. 8** along with the bandwidth of a 1:4 coax balun for comparison. My measurements indicate that the pi net built as shown will transform resistive impedances between 6 and 14 ohms with VSWR less than 1.7 at 7 MHz. Phase imbalance caused by component tolerances was not evaluated but probably is no worse than that of a balun. If you choose to build the coax balun instead of the pi net, RG-58/U should be suitable for a kilowatt. **Figure 8** shows details of this unconventional coax balun.

A 1:4 ferrite balun design isn't shown but should perform equally well if attention is given to the design of the balun windings. Remember: to transform 12 ohms to 48 ohms, it's important that the Z_0 of the balun windings be the square root of quantity $12 \times 48 = 24$ ohms to avoid introducing reactances, thereby reducing the already narrow bandwidth. A low Z_0 requires large-gauge (No. 14 or larger) wire, preferably bifilar wound. And unless you can find a 1:4 balanced-to-unbalanced design (I couldn't), you will have to use two baluns back to back, perhaps a 1:4 balanced-to-balanced followed by a 1:1 balanced-to-unbalanced. These difficulties led me to opt for Dietrich's[2] 1:4 balanced-to-balanced coax balun as

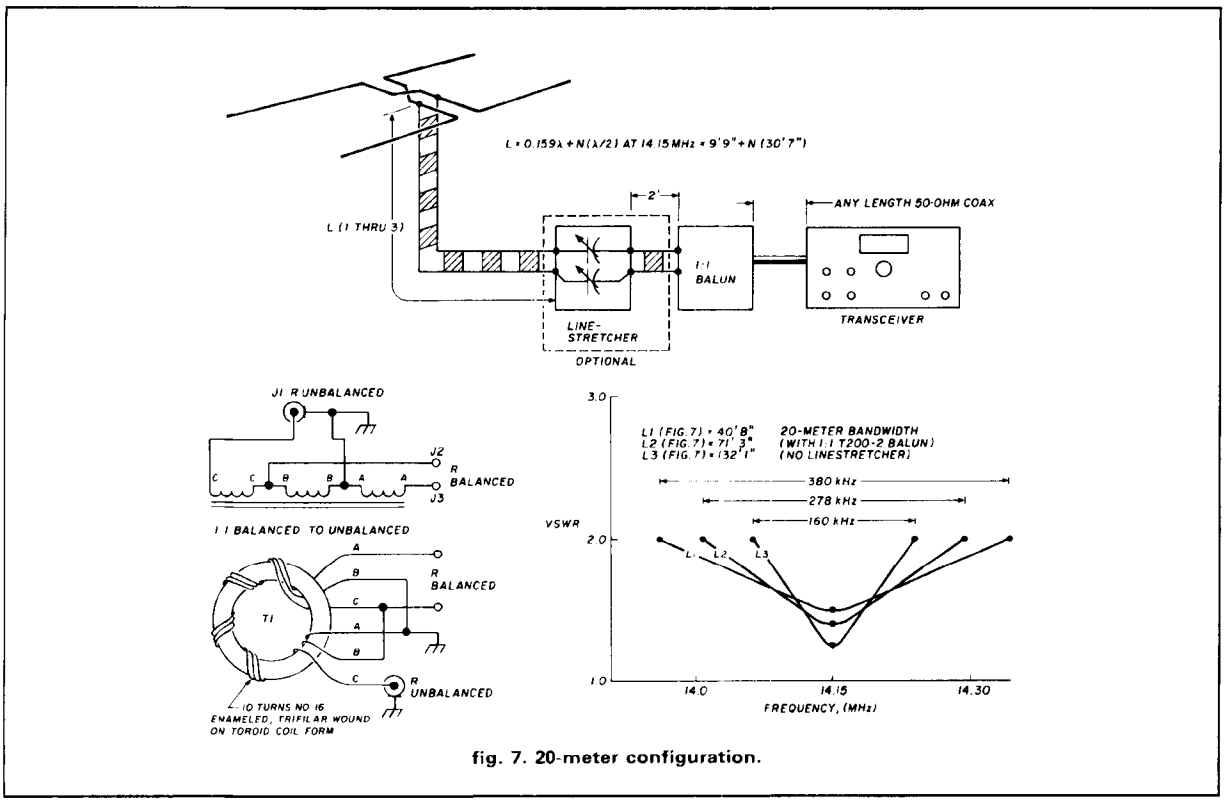


fig. 7. 20-meter configuration.

an alternate to the pi net. The main disadvantage of the coax balun is the bulk of the coax cable.

Determine feedline length from the Smith Chart shown in fig. **3**. The wavelength is 0.495 at 7.15 MHz between point B clockwise to point A, where the feedpoint impedance is resistive. Substituting into $L = (N \bullet 984 \bullet V_f)/F$

Where N = 0.495, V_f = 0.88, and F = 7.15 MHz gives the required length in feet. For example, 450-ohm ladder line with V_f = 0.88 requires a length of 60 feet. Any number of half wavelengths can be added to this to reach the transmitter without affecting the impedance at the line input (neglecting losses). Note that feedline length does affect operating bandwidth, as evidenced by the VSWR curves plotted for different feedline lengths in figs. **6** and **7**.

The 8-foot length of line connecting the line stretcher to the pi net is negated by the capacitive reactance introduced by the line stretcher with the plates meshed halfway at 7.15 MHz. The effects of the two cancel each other. Increasing or decreasing capacitance, then, adds or subtracts feedline to maintain a resistive input impedance over the 7.0- to 7.3-MHz band. Line stretcher reactance range at 7 MHz is indicated by the pie-shaped region on the Smith chart of fig. **3**.

If you calculate the proper length as shown above, 300-ohm TV line should be acceptable for low-power, single-band operation on 40 meters. However, if you operate on 20 meters, 450-ohm line should be used (unless you use a transmatch). The line, in this instance, acts as a transmision line and also an impedance-transforming line section to get the input impedance reasonably close to 50 ohms.

operating on 20 meters without a transmatch

Operating this antenna using tuned feeders without a transmatch (**fig. 7**) is much easier on 20 meters than on 40. The antenna's impedance transforms to near 34 ohms using the properties of 450-ohm ladder line. Bandwidth at the VSWR = 2 points is approximately 160 to 380 kHz, depending on feedline length. Use of the line stretcher is optional unless feedline length is excessive. Bandwidths for three feedline lengths are shown in **fig. 7**.

Line stretcher setup and use are similar to that for 40 meters, but approximately 2 feet are used to interconnect it and the 1:1 balun. Line stretcher tuning range at 14 MHz drops because of the decreased reactance of the line stretcher capacitors, so using smaller value fixed capacitors may help.

The 1:1 balun can be a coax or an air-core/toroidal design. An air-core or toroidal design in this application is relatively simple when compared to the design of the 12- to 48-ohm balun used on 40 meters. The required impedance of the windings is near 41 ohms.

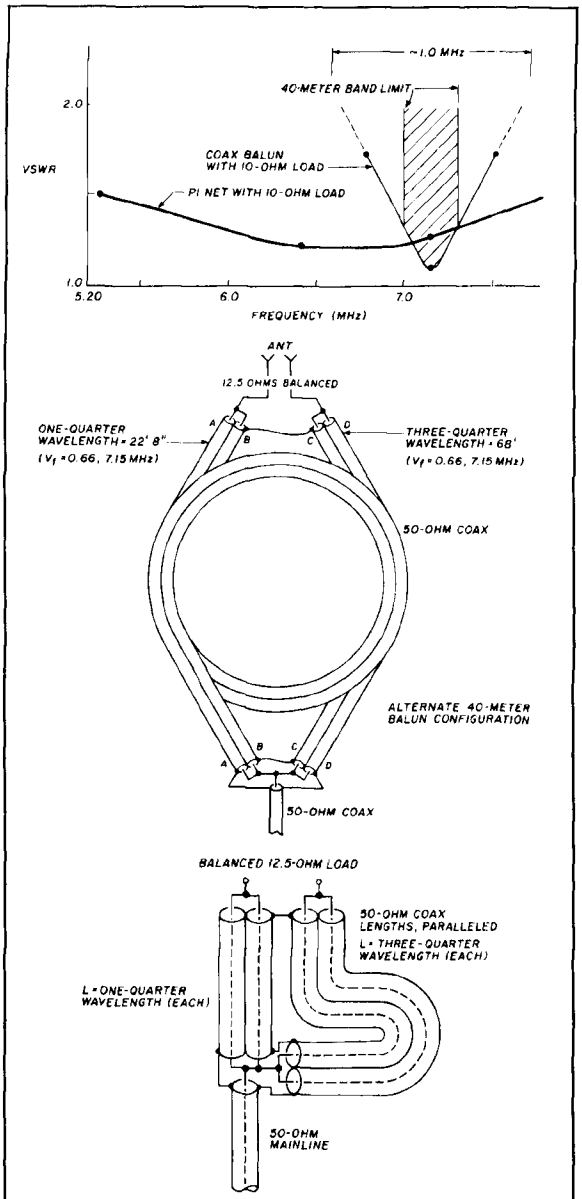


fig. 8. Bandwidth of the pi net and details of coax balun.

The balun can be easily made with ten turns, trifilar wound (this works best) of No. 16 gauge enameled wire, on an air or powered iron core. The core should be large enough to handle your anticipated running power. A T-200-2 core should handle up to a kilowatt when operating within the VSWR = 2 bandwidth. **Fig. 7** shows a toroid balun built along these guidelines.

On 20 meters, feedpoint impedance (point C on the Smith chart in **fig. 3**) is close to 106 − j578 ohms. You can use a 0.159 λ + N•(λ/2) length of 450-ohm feedline (measured Z_0 of 385 ohms) to transform this to approximately 34 ohms at the input end. See **fig. 7**. The length of feedline required is 9 feet 9 inches + (30 feet 7 inches)N, to operate at 14.15 MHz (V_f = 0.88).

Using 450-ohm feedline is important because, unlike a simple half wavelength of feedline, an arbitrary length of feedline will transform impedances as a function of line length and Z_0 of the line. For example, the 450-ohm ladder line I used had a measured Z_0 of approximately 385 ohms and $V_f = 0.88$ [see **ref. 3**]. The feedpoint impedance, point C on the **fig. 3** Smith chart, along a 0.159 wavelength section of feedline transforms to about 34 ohms. Using 300-ohm line as a transformer results in a transformed impedance of close to 23 ohms (VSWR = 2.2 at $Z_0 = 50$ ohms). This reduces the usable bandwidth somewhat as compared to 450 ohm line. Similarly, using 600-ohm open-wire line will result in a transformed impedance of approximately 58 ohms. Line with an actual Z_0 of 450 ohms transforms to approximately 42 ohms. Use these figures as a guide if you plan to try different feedlines. Remember that the above figures are based on an antenna with 59-foot elements spaced 16 feet apart and about 40 feet above average soil. Unless the phasing line section is closely duplicated, you will probably get slightly different resistive impedances at the feedline input and have to trim the feedline lengths. Don't let this discourage you — the pi net described in **fig. 6** is a neat and simple solution to the impedance transformation problem, once you measure the feedline input impedance with an rf or noise bridge.

operating on 30 meters

This antenna can also be operated on 30 meters by adjusting the length of the feedline. With 30 feet 2 inches + (42 feet 10 inches)N of feedline ($V_f = 0.88$), the input impedance will be approximately 23 ohms. A pi net constructed using information in **fig. 6** should give a good match and ample bandwidth. While I have not measured the radiation pattern, I would guess it's probably not a lot different from the 40- or 20-meter patterns.

Building and evaluating this rather unconventional antenna took me about a year. I hope the information here helps you better understand and build the W8JK. Any questions accompanied by an SASE are welcome.

references

1. L.A. Muxon, *HF Antennas For All Locations*, Radio Society of Great Britain, Great Britain, 1982.
2. Jim Dietrich, "A New Coaxial Balun," *ham radio*, May 1977.
3. George Downs, "Measuring Transmission-line Velocity Factor," *QST*, June 1979.
4. *The ARRL Antenna Handbook*, Chapter 4, 14th Edition, 1984.
5. Frank Regier, "A New Look at the W8JK Antenna," *ham radio*, July 1981.
6. John Kraus, "The W8JK Antenna: Recap and Update," *QST*, June 1982.
7. Leonard Anderson, "Antenna Bridge Calculations," *ham radio*, May 1978.
8. William I. Orr, W6SAI, *Radio Handbook*, Howard W. Sams Co., Indianapolis, Indiana, 1981 Edition, page 26.11.

ham radio

pathfinder:
improved minimuf program

Gray-line analysis, dist/az determination and radial/hourly muf prediction

Personal computer applications offer hams programs providing distance/azimuth determinations and ionospheric propagation predictions. They are used to determine operating band choice and antenna direction. Though several bearing/distance and gray-line programs exist, MINIMUF is the main ionospheric prediction routine used in Amateur Radio.[1]

The original BASIC MINIMUF version, required only 4 to 6K of instruction and dynamic storage. The *QST* article that introduced MINIMUF concentrated on the genesis of its algorithms and ionospheric modeling and provided an elementary user guide.

initial goals

I wanted to and succeeded in improving MINIMUF's speed. Then two articles by Elwell made me think that a lot more could be done to build a truly useful program.[2,3] I had already merged MINIMUF into a gray-line program[4] and had been using a bearing/distance program.[5] **Figure 1** is a listing of a complete program that does it all.

PATHFINDER is longer than MINIMUF though not much faster. It is more powerful than the older version of MINIMUF as it uses the upgrade (MINIMUF-85) that models polar paths much more accurately, and takes into account many variable factors that the previous version (MINIMUF-3.5) did not.[6,7]

MINIMUF-85 is an empirically derived model that predicts near real time MUF, developed by the Naval Ocean System Center*.[8] After having developed my original program around MINIMUF-3.5 I was sure that its improvement in speed could be put to use more efficiently. I contacted Bob Rose, K6GKU, and, received a copy of MINIMUF-85. I was able to upgrade PATHFINDER to the new algorithm and verify it. The older programs have been in use for some time and have been documented. The Navy has tested and verified MINIMUF-85 and now recommends it for use in all applications currently using MINIMUF-3.5.

inside MINIMUF

The MINIMUF algorithms follow a well-established procedure for determining both the MUF and preferred operating frequency. This procedure:

- Describes the path of interest in terms of its control points (locations 2000 km from each end of the path).
- Plots these points on a transparent overlay that is placed on a map of the earth.
- Records the MUF at the control points by reading the map MUF contours.

Determine the path MUF for a particular time and day by referring to additional charts and making calculations. The maps are keyed to solar activity, angle of incidence, time of day and year. This manual method has been described in the Amateur literature.[9]

The key to MINIMUF is the model of the ionosphere, found in the last two dozen lines of the original program code. This algorithm implements the characteristics of the maps used in the manual method. All of the code in MINIMUF preceding this model defines the number and location of the control points and the

*The NOSC technical publications for MINIMUF-3.5 and MINIMUF-85 are available through NTIS; 5285 Port Royal Road, Springfield, Virginia 22161. See *ham radio*, July 1987, page 49.

By Ron Todd, K3FR, 7 Hillcrest Road, Windham, Maine 04062

fig. 1. The PATHFINDER program.

```
10 PRINT "     Welcome to PATHFINDER-85"
20 PRINT "COPYRIGHT 1987 by Ronald C. Todd"
30 'MICROSOFT BASIC version, Release 1.10, 2/2/88
40 DIM M(12),WW(19),LL(19),K9(19),SR(19),SS(19)
50 DIM C0(19),T9(19),ZW(19),YX(19),YS(19),ZX(19)
60 DIM FF(19),LG(19),GF(19),G7(19),G8(19),ZZ(19),MOUT(36)
70 DEFINT I: M$="JanFebMarAprMayJunJulAugSepOctNovDec"
80 DATA 31,28,31,30,31,30,31,31,30,31,30,31
90 DATA -.06,-.037,.018,-.003,.025,.018
100 DATA .007,-.005,.006,.017,-.009,-.004
110 DATA 3.83,-22.915,-7.317,.51,.06,-.43,-9.471,-3.197
120 DATA -.082,-.156,-.391,-.106,0,0,-.242,-.15
130 DATA .011,.087,-.043,.003,-.013,-.022,.003,0,.005,0,0,.018
140 FOR I=1 TO 12: READ M(I): NEXT I: PI=3.14159: P0=PI/2
150 P1=2*PI: P2=2/PI: P5=PI/5: P6=SIN(PI/12): R0=PI/180
160 R1=180/PI: CC=-23.5*R0: LH=43.7876: WH=70.4348 'home
170 GOSUB 8000: GOSUB 8200: GOSUB 8400: GOSUB 8520: GOSUB 7200
200 INPUT "Opt: 1=Input 2=Anal 3=List 4=Quit ";IO
210 ON IO GOTO 220,240,280,9999: GOTO 200
220 INPUT "Opt: 0=Top 1=Date 2=Flux 3=SSN 4=Target 5=Home ";IO
230 ON IO GOSUB 8000,8200,8300,8400,8500: GOSUB 7200: GOTO 200
240 IL=0: S6=0: INPUT "Opt: 0=Top 1=B/D 2=Grey 3=MUF ";IO
250 ON IO GOSUB 1400,1300,260: GOTO 200
260 S6=P6: INPUT "Opt: 0=Top 1=Short 2=Long 3=Radial ";IO
270 ON IO GOSUB 1010,1000,1100: RETURN
280 IF IL=2 THEN I=18: IA=10 ELSE I=12: IA=100
290 LPRINT "GMT/DEG","MUF","GMT/DEG","MUF"
300 FOR IH=0 TO I-1: FOR IB=0 TO I STEP I
310 LPRINT (IH+IB)*IA,MOUT(IH+IB),
320 NEXT IB: LPRINT: NEXT IH: GOTO 200
1000 IL=1                              'HOURLY MUF DRIVER
1010 GOSUB 8420: GOSUB 3000: GOSUB 4000: GOSUB 3100
1020 GOSUB 7100: PRINT "GMT","MUF","GMT","MUF"
1030 FOR IH=0 TO 11                    'SWEEP TIME
1040 FOR IB=0 TO 12 STEP 12: T5=IH+IB: GOSUB 2000
1050 PRINT T5*100,J9;"      ",;: MOUT(IH+IB)=J9
1060 NEXT IB: PRINT: NEXT IH: RETURN
1100 INPUT "What GMT hour for display";T5 'RAD MUF SETUP
1110 IL=2: IF (T5>=24 OR T5<0) THEN PRINT "ERROR": GOTO 1100
1120 PRINT "1 Hop = 2488 mi (4000 Km). Long Path beyond 5"
1130 INPUT "How many hops for display [0.1 to 9.9]";K1
1140 IF ABS(K1-5)>4.9 THEN PRINT "ERROR": GOTO 1130
1150 G1=K1*P5: GOSUB 4000: PRINT "DEG","MUF","DEG","MUF"
1160 FOR IH=0 TO 170 STEP 10                'SWEEP BEARING
1170 FOR IB=0 TO 180 STEP 180: A0=IH+IB
1180 IF IH=0 THEN PB=(A0+.1)*R0 ELSE PB=A0*R0
1190 A=COS(PB): B=G1: GOSUB 3300: L2=L0: GOSUB 3100
1200 GOSUB 2000: PRINT A0,J9;"      ",;: MOUT(A0\10)=J9
1210 NEXT IB: PRINT: NEXT IH: RETURN
1300 W0=W1: L0=L1: GOSUB 5000: PRINT "At home QTH": GOSUB 7000
1310 GOSUB 8420: W0=W2: L0=L2: GOSUB 5000: PRINT "At targ QTH"
1320 GOSUB 7000: RETURN
1400 GOSUB 8420: GOSUB 3000: GOSUB 7100
1410 IL=1: GOSUB 3000: GOSUB 7100: RETURN
2000 J9=100: FOR I=1 TO IK                  'MUF SET UP
2010 SLT=T5-WW(I)*P2*6: IF SLT<0 THEN SLT=SLT+24
2020 IF SLT>=24 THEN SLT=SLT-24
2030 G0=0: SAD=1: IF C0(I)<=-P6 THEN 2300
2040 IF SS(I)<SR(I) THEN 2060              'INVERTED DAY
2050 IF (T5-SR(I))*(SS(I)-T5)<0 THEN 2200 ELSE 2100
2060 IF (T5-SS(I))*(SR(I)-T5)>0 THEN 2200 ELSE 2100
2100 IF SR(I)>T5 THEN X=T5+24 ELSE X=T5          'DAY G0
2110 YM=PI*(X-SR(I))/K9(I): X=(SR(I)-X)/T9(I)
2120 GOSUB 6100: FM=X
2130 G0=(SIN(YM)+ZW(I)*(EXP(FM)-COS(YM)))*G8(I)
2140 SAD=1.11-.01*SLT: IF G0<G7(I) THEN G0=G7(I)
2150 GOTO 2300
2200 IF SS(I)>T5 THEN X=T5+24 ELSE X=T5          'DARK G0
2210 SAH=P1*(14*(X-SS(I))/(24.01-K9(I))+1)/15
2220 FM=(SS(I)-X)/2: SAD=1.0195: RESTORE 90
2230 FOR IA=1 TO 6: Y=IA*SAH: READ C1,C2
2240 SAD=SAD+C1*SIN(Y)+C2*COS(Y): NEXT IA
2250 G0=ZZ(I)*EXP(FM)
2300 G2=SQR(6+A1*SQR(G0))+GF(I)              'RAW FoF2
2310 G2=G2*(1-.1*EXP((K9(I)-24)/3))         'LONG DAY ADJ
2320 G2=G2*(1+(1-SGN(L1)*SGN(L2))*.1)        'TRANS E ADJ
2330 G2=G2*(1-.1*(1+SGN(ABS(SIN(LL(I)))-COS(LL(I))))) 'HI LAT
2340 SAE=A2*A3*SAD: IF ABS(LG(I))<.95993 THEN 2600
2400 PHI=SLT*PI/12: V=SIN(Y1/2): IF LG(I)>0 THEN 2430  'POLAR
2410 X=EXP(-1.2*(COS(LG(I)+CC*COS(PHI))-COS(LG(I))))
2420 PLR=(2+.012*S9)*X*(1+.3*V): GOTO 2480
2430 U=COS(Y1): X=V*(.5*(YX(I)-ZX(I))-YX(I)^8)
2440 X=X-(1+V)*U*SGN(ZX(I))*SQR(ABS(ZX(I)))*EXP(-4*YX(I)^2)
```


RF POWER TRANSISTORS

We stock a full line of Motorola & Toshiba parts for amateur, marine, and business radio servicing

SEE YOU AT DAYTON BOOTH 360

Partial Listing of Popular Transistors

2-30 MHz 12V. (28V)*

P/N		Rating	Net Ea	Match Pr.
MRF421	Q	100W	$24.00	$53.00
MRF422*		150W	36.00	78.00
MRF454/A	Q	80W	14.50	32.00
MRF455/A	Q	60W	11.75	26.50
MRF485*		15W	6.00	16.00
MRF492	Q	90W	16.00	35.00
SRF2072	Q	65W	12.75	28.50
SRF3662	Q	110W	24.00	53.00
SRF3775	Q	75W	13.00	29.00
SRF3795	Q	90W	15.50	34.00
SRF3800	Q	100W	17.50	38.00
2SC2290	Q	80W	16.75	39.50
2SC2879	Q	100W	22.00	48.00

Q Selected High Gain Matched Quads Available

VHF UHF TRANSISTORS 12V.

	Rating	MHz	Net Ea.	Match Pr.
MRF245	80W	136-174	27.50	61.00
MRF247	75W	135-174	26.00	58.00
MRF248	80W	136-174	33.00	71.00
MRF641	15W	407-512	18.00	42.00
MRF644	25W	407-512	21.00	46.00
MRF646	40W	407-512	25.00	54.00
MRF648	60W	407-512	31.00	66.00
2N6080	4W	136-174	6.25	—
2N6081	15W	136-174	8.00	—
2N6082	25W	136-174	9.50	—
2N6083	30W	136-174	9.75	24.00
2N6084	40W	136-174	11.50	28.00

PARTIAL LISTING OF MISC. TRANSISTORS

MRF134	$16.00	MRF515	2.50
MRF136	21.00	MRF607	2.50
MRF137	24.00	MRF630	4.25
MRF138	35.00	MRF846	43.50
MRF174	80.00	MRF1946,A	14.00
MRF208	11.50	CD2545	16.00
MRF212	16.00	SD1278-1	17.75
MRF221	11.00	2N3553	2.29
MRF224	13.50	2N3866	1.25
MRF237	2.70	2N4427	1.25
MRF238	12.50	2N5589	7.25
MRF239	14.00	2N5590	10.00
MRF240	15.00	2N5591	13.50
MRF260	7.00	2N5641	9.50
MRF261	8.00	2N5642	13.75
MRF262	8.75	2N5643	15.00
MRF264	12.50	2N5945	10.00
MRF309	29.75	2N5946	12.00
MRF317	56.00	2SC1946,A	15.00
MRF406	12.00	2SC1947	9.75
MRF433	11.00	2SC2075	3.00
MRF449	12.50	2SC2097	28.00
MRF450	13.50	2SC2509	9.00
MRF453	15.00	2SC2640	15.00
MRF458	20.00	2SC2641	16.00
MRF475	3.00	*OUTPUT MODULES*	
MRF476	2.75	SAU4	55.00
MRF477	11.75	SAU17A	50.00
MRF479	10.00	SAV6	42.50
MRF492A	18.75	SAV7	42.50
MRF497	14.25	SAV15	48.00
40582	7.50	M57712, M57733	use SAV7
NE41137	2.50	M57737, SC1019	

Hi-Gain, Matched, and Selected Parts Available

We stock RF Power transistors for Atlas, KLM, Collins, Yaesu, Kenwood, Cubic, Mirage, Motorola, Heathkit, Regency, Johnson, Icom, Drake, TWC, Wilson, GE, etc. Cross-reference on CD, PT, SD, SRF, JO, and 2SC P/Ns.

Quantity Pricing Available Foreign Orders Accepted

Shipping/Handling $5.00 COD / VISA / MC

Orders received by 1 PM PST shipped UPS same day. Next day UPS delivery available

ORDER DESK ONLY — NO TECHNICAL

(800) 854-1927

ORDER LINE and/or TECH HELP

(619) 744-0728

FAX (619) 744-1943



RF PARTS

1320 Grand Avenue
San Marcos, CA 92069

CIE Cleveland Institute of Electronics

1776 East 17th St., Cleveland, Ohio 44114

Accredited Member National Home Study Council

CIE is the world's largest independent study electronics school. We offer ten courses covering basic electronics to advanced digital and microprocessor technology. An Associate in Applied Science in Electronics Engineering Technology is also offered.

Study at home — no classes. Programs accredited and eligible for VA benefits.

CIE Cleveland Institute of Electronics
1776 East 17th St., Cleveland, Ohio 44114

YES! I want to get started. Send me my CIE school catalog including details about the Associate Degree program.

Print Name _____

Address _____ Apt. _____

City _____ State _____ Zip _____

Age _____ Area Code/Phone No. _____

Check box for G.I. Bulletin on Educational Benefits

☐ Veteran ☐ Active Duty MAIL TODAY!

AHR-01

✓ 189

MADISON

Electronics Supply, Inc.

3621 Fannin St. • Houston, Texas 77004

COOPER INDUSTRIES **BELDEN**

✓ 190

BELDEN

9913 low loss, solid center conductor, foil & braid shield - excellent product	54¢/ft
8214 RG8 foam	43¢/ft
8237 RG8	40¢/ft
8267 RG213	52¢/ft
8262 RG-58 c/u milspec	16¢/ft
8000 14ga stranded copper ant. wire	13¢/ft
8448 8 conductor rotor cable	31¢/ft
9405 as above but HD—2.16ga. 6-18ga	.52¢/ft
8403 Mic cable 3 condctr & shield	80¢/ft
100 feet 8214 wends installed	45.00
9258 RG 8X	19¢/ft

POLICIES--MASTERCARDS, VISA or C.O.D

All prices FOB Houston, Texas, except as noted. Prices subject to change without notice, subject to prior sale. Used gear sale price refunded if not satisfied. Call anytime to check status of your order. Texas residents add sales tax.

FOR MORE INFORMATION CALL

outside Texas

1-800-231-3057

Texas and outside US

1-713-520-7300

```
2450 PLR=2.5+.02*S9+U*(.5+(1.3+.002*S9)*YS(I))
2460 PLR=PLR+(1.3+.005*S9)*COS(PHI-PI*(1+X))
2470 PLR=PLR*(1+.4*(1-V*V))*EXP(-V*YS(I))
2480 X=(1-FF(I))*G2*G2/8.12+.66*FF(I)*PLR
2490 IF X>=0 THEN G2=2.85*SQR(X)
2600 G2=G2*M9*SAE: IF G2<J9 THEN J9=G2              'FIN MUF
2610 NEXT I: IF J9<2 THEN J9=2 ELSE IF J9>50 THEN J9=50
2620 J9=INT(10*J9)/10: RETURN
3000 X=SIN(L1)*SIN(L2)+COS(L1)*COS(L2)*COS(W2-W1): GOSUB 6000
3010 G1=X: X=(SIN(L2)-SIN(L1)*COS(G1))/(COS(L1)*SIN(G1))
3020 GOSUB 6000: IF SIN(W2-W1)>0 THEN PB=P1-X ELSE PB=X
3030 IF IL=1 THEN PB=PB+PI: G1=P1-G1
3040 IF PB>P1 THEN PB=PB-P1
3050 A=COS(PB): RETURN
3100 FOR I=1 TO IK: GF(I)=0: B=I*L          'POINT DEF & PARAM
3110 IF G1<=.94174 THEN B=1/(2*K6)+(I-1)*(.9999-1/K6)
3120 B=B*G1: GOSUB 3300: GOSUB 3400: WW(I)=W0: LL(I)=L0
3130 SM=.9792*SIN(L0)+.2028*COS(L0)*COS(W0-1.2043): X=SM
3140 GOSUB 6000: LG(I)=P0-X: IF ABS(LG(I))<.95993 THEN 3210
3150 SM=SIN(LG(I)): GF(I)=.3789*SQR(1+3*SM^2)-.5: Y=COS(LG(I))
3160 X=2.2+(.2+.001*S9)*SM: X=(X*Y)^6: GOSUB 6100
3170 FF(I)=EXP(-X): IF LG(I)<0 THEN 3210
3180 X=COS(L0)*SIN(W0-1.2043)                   'GEOMAG LONG
3190 IF Y=0 THEN X=P0*SGN(X) ELSE X=X/Y: GOSUB 6000: X=P0-X
3200 YX(I)=SIN(X/2): YS(I)=(COS(X/2-PI/20))^4: ZX(I)=SIN(X)
3210 GOSUB 5000: NEXT I: RETURN
3300 C=P*COS(B)+Q*SIN(B)*A: X=C: GOSUB 6000: L0=P0-X: RETURN
3400 X=(COS(B)-COS(X)*P)/(Q*SIN(X)): GOSUB 6000
3410 IF SIN(PB)<0 THEN W0=W1+X ELSE W0=W1-X
3420 IF ABS(W0)>PI THEN W0=W0-P1*SGN(W0): GOTO 3420
3430 RETURN                                     'POINT LONG
4000 IF G1<=P5 THEN K6=1: M9=1 ELSE K6=G1/P5: M9=.5
4010 M9=2.5*G1*M9: IF M9>P0 THEN M9=1 ELSE M9=SIN(M9)
4020 M9=1+2.5*M9*SQR(M9): IK=INT(G1/.62784)+1: L=1/(2*IK)
4030 IF G1>.94174 THEN IK=2*IK-1
4040 RETURN
5000 C0(I)=COS(L0+Y2): C0A=ABS(C0(I))          'DAYLIGHT CHAR
5010 IF C0(I)<-S6 THEN K9(I)=0: GOTO 5110       'SUNR CHECK
5020 K8=6*(2+W0*P2)-ET                          'NOON
5030 IF K8<0 THEN K8=K8+24 ELSE IF K8>=24 THEN K8=K8-24
5040 X=(SIN(Y2)*SIN(L0)-S6)/(COS(Y2)*COS(L0)+.001)
5050 GOSUB 6000: X=6*X*P2: K9(I)=2*X            'LEN DAY
5060 SR(I)=K8-X: IF SR(I)<0 THEN SR(I)=SR(I)+24     'SUNR
5070 SS(I)=K8+X: IF SS(I)>=24 THEN SS(I)=SS(I)-24   'SUNS
5080 IF C0A<.62094 THEN T9(I)=.1 ELSE T9(I)=9.7*C0A^9.6
5090 X=K9(I)/T9(I): ZW(I)=PI/X: G8(I)=C0A/(1+ZW(I)^2): GOSUB 6100
5100 ZZ(I)=(EXP(-X)+1)*ZW(I)*G8(I): G7(I)=EXP((K9(I)-24)/2)*ZZ(I)
5110 RETURN
6000 IF ABS(X)>=1 THEN X=P0*SGN(X) ELSE X=ATN(X/SQR(1-X*X))
6010 X=P0-X: RETURN
6100 IF ABS(X)>87 THEN X=87*SGN(X)
6110 RETURN
7000 IF C0(I)<=0 THEN PRINT "Day not defined": GOTO 7050
7010 PRINT "Sunrise at:";INT(40*INT(SR(I))+60*SR(I))/100;"Z"
7020 PRINT "Sunset  at:";INT(40*INT(SS(I))+60*SS(I))/100;"Z"
7030 PRINT "Day length:";INT(40*INT(K9(I))+60*K9(I))/100;"HR.MIN"
7040 PRINT "Noon    at:";INT(40*INT(K8)+60*K8)/100;"Z"
7050 RETURN
7100 PRINT "Path length =";INT(G1*3959);"miles"
7110 PRINT "Path bearing at home QTH =";INT(PB*R1): RETURN
7200 PRINT "DATE: "MID$(M$,3*M0-2,3)" "D6
7210 PRINT "HOME AT LAT"LH"LONG"WH" TARGET AT LAT"LT"LONG"WT
7220 PRINT "SOLAR FLUX="SX" SUN SPOT NUMBER="S9: RETURN
8000 INPUT"Month number";M0: INPUT"Day of month";D6: Y1=D6
8010 FOR I=1 TO M0-1: Y1=Y1+M(I): NEXT I: Y1=Y1*P1/365
8020 Y2=.456: ET=.008: RESTORE 110
8030 FOR I=1 TO 4: X=I*Y1: READ C1,C2,C3,C4
8040 Y2=Y2+C1*SIN(X)+C2*COS(X): ET=ET+C3*SIN(X)+C4*COS(X): NEXT I
8050 Y2=-Y2*R0: ET=ET/60: KX=M0*PI/6: A3=.9925: RESTORE 130
8060 FOR I=1 TO 6: X=I*KX: READ C1,C2
8070 A3=A3+C1*SIN(X)+C2*COS(X): NEXT I: RETURN
8200 INPUT"Solar Flux [64 to 301]";SX
8210 S9=INT((-.728+SQR(.529984-(63.75-SX)*.00356))/.00178)
8220 A1=.814*S9+22.23: A2=1.3022-.00156*S9: RETURN
8300 INPUT"Sun Spot Number [0 to 250]";S9
8310 SX=63.75+.728*S9+.00089*S9*S9:GOTO 8220
8400 INPUT"Target Latitude [- south, 89.9 max]";LT
8410 INPUT"Target Longitude [- east]";WT
8420 L2=LT*R0: W2=WT*R0: RETURN
8500 INPUT"Home Latitude [- south, 89.9 max]";LH
8510 INPUT"Home Longitude [- east]";WH
8520 L1=LH*R0: W1=WH*R0: P=SIN(L1): Q=COS(L1): RETURN
9999 END
```

determination of the geometry of the solar illumination of these points at the time of analysis on the day selected.

The basis for the MINIMUF model is that MUF is a function of the product of the critical frequency of the ionosphere and a path-related M-factor. MINIMUF-3.5 uses fairly simple relationships to model these functions. MINIMUF-85 expands on these primary relationships, considers more control points on longer paths and takes into account the special conditions in polar regions.[10] MUFs are affected differently when control points fall within polar regions. MINIMUF-85 factors in sunspot number-related effects to the critical frequency and M-factor, adds seasonal and diurnal variation to the M-factor, and considers particle precipitation effects for control points in or near polar regions.

The MINIMUF-85 model reduces the RMS errors in MUF for polar paths from the older MINIMUF version of 10.92 MHz to 3.5 MHz, and improves the overall average bias in MUF predictions. The lack of correlation between solar flux and smoothed sunspot numbers can still amount to significant errors in the predicted MUF. It is recommended that you use average values of solar flux as the input variable because the F-layer of the ionosphere has a lot of inertia and does not easily respond to short-term changes in solar conditions.

There is considerable math and physics involved. Consequently, many users do not realize that MINIMUF depends heavily on the same routines and algorithms necessary to implement bearing/distance and gray-line analysis applications. MINIMUF can be made to report this information without requiring much additional code. Using these same routines, the MUF can be determined for radial presentation for any hour of the day and path length. MINIMUF can produce an application providing virtually all the information required by the average hf operator. Further, by accessing a world data file of latitudes and longitudes keyed to call prefixes, we could generate a product for all DXers.

basic program requirements

The first step in designing PATHFINDER was to define the tasks it would accomplish; below is a list of these primary features.

- HOURLY MUF PROJECTIONS SHORT PATH
- HOURLY MUF PROJECTIONS LONG PATH
- RADIAL MUF PROJECTIONS 250 TO 22500 MILES
- BEARING AND DISTANCE REPORT SHORT PATH
- BEARING AND DISTANCE REPORT LONG PATH
- PATH GRAY-LINE REPORT
- MINIMUM CODE SIZE
- MINIMUM RESPONSE TIME
- POSSIBLE HOOKS TO LAT/LONG DATA FILE

Next, I surveyed MINIMUF and several bearing/distance and gray-line programs for comparable features, algorithms, and routines.

The subsequent steps were easier once I had decided on the program requirements. Program flow and variable requirements were evaluated for all these sources *before* setting down a single line of pseudocode. I planned what I needed and how I would accomplish it with minimum overhead. The increased computational burden in PATHFINDER does not cause a major increase in total response time when compared to MINIMUF in identical applications. The reason for the significant improvement in performance while model sophistication and computation have grown by nearly 100 percent is a result of four basic concepts described next.

speed increase

First, MINIMUF spends a lot of time in its loops recalculating variables which, once they are determined, do not change. All computations not absolutely necessary to repeat have been moved out of the loops, precalculated, and placed in arrays. Computation time is saved with only a minimal increase in storage requirements. The general purpose procedures are now subroutines supporting the other applications of the program. Second, where prudent, the use of the division operation, has been minimized particularly in repeated sequences. Third, where possible, control statements have been restructured to function on integer and simple variables rather than real variable types and compound functions. Finally, multiple program statements have been placed on a single logical line which helps most BASIC language interpreters run faster.

Two versions of PATHFINDER as well as MINIMUF have been timed in generating hourly MUF projections. The results of this bench mark over several paths are shown in **table 1**. All results were of equivalent accuracy with no significant discrepancies in projected MUF except where the MINIMUF-85 algorithm provides more credible values. It is evident from **table 1** that PATHFINDER, because it has to set up its variables before path analysis starts, requires more time to return the projection for 0000 UTC. But PATHFINDER quickly generates the MUF projections for the rest of the day. PATHFINDER in either form is comparable or superior to MINIMUF in total response time. PATHFINDER without increased speed would be intolerably slow in executing the MINIMUF-85 algorithms.

The number of control points evaluated on a given path is a significant difference in the three programs. For the short paths all of the programs evaluate at only one point. The two earlier versions determined values

Table 1. Propagation path calculation time (seconds) using three different programs.*

Path	FIRST/TOTAL		FIRST/TOTAL		FIRST/TOTAL	
2000 km midlatitude	<1	49	3	19	3	25
6000 km midlatitude	<1	88	3	31	5	79
6000 km polar summer	<1	90	4	26	6	106
6000 km polar winter	<1	86	5	30	6	91

* "FIRST" is the time needed to calculate the first hour's value.
"TOTAL" is the time needed to calculate the entire day's (24 hours) values.

at only two points for *longer* paths, while the MINIMUF-85 version of PATHFINDER can evaluate up to 19 points for a nearly circumferential long-path projection. The additional computations required when a point falls within a polar region is another difference. This can easily double the evaluation time per point. The changes appear when radial projections are run since the program must compute a new path and all path and point-related variables with each increment in bearing, in addition to evaluating each point.

program "construction"

PATHFINDER uses the "top-down" programming technique which starts out broad and develops a level at a time. The detail becomes finer for each successive level. The flow of PATHFINDER follows this concept reasonably well. The menu loop is entered after the program constants are set up calling subroutines that call other subroutines until the chosen analysis is performed and the program returns to the menu level.

Looking down inside the input routines, you first have data entry followed by conversions and variable computations for each point. Each input routine processes only its own variables since, with the menu interface, it is necessary to redo some computations previous to or within the simulation setups when input conditions change.

Each of the modes (bearing/distance gray-line, radial and hourly) is driven by an independent setup routine assuring correct results regardless of the others. In this way, you might change the solar flux input and rerun a path evaluation or, once you have a path evaluation, determine the gray-line parameters for the path end points. Each driver sets up the variables necessary for its function and calls the analysis to be executed. The partitioning of the variable setups maintains related computations in the same routine so that duplication of code and computation are minimized, and at the same time, program utility is expanded. Unnecessary computations are bypassed whenever possible.

Table 2. Long-path calculation.*

Propagation for: DEC 21
Home QTH, Lat: −87 Lon: 130
Target QTH, Lat: 80 Lon: 310
Solar flux = 150 Sunspot number = 104
Path length = 12920 miles
Path bearing = 0

GMT	MUF	GMT	MUF	GMT	MUF	GMT	MUF
0000	9.6	0600	8.9	1200	12.5	1800	11.9
0100	10.8	0700	10.4	1300	11.3	1900	12.7
0200	9.5	0800	9.1	1400	10.7	2000	11
0300	9.2	0900	12.8	1500	11.2	2100	10.4
0400	10.5	1000	13.3	1600	15	2200	11.4
0500	9.3	1100	12.7	1700	12.8	2300	10.

*All major program sections are exercised.

Bench marks were run on a 2-MHz Kaypro II under Microsoft BASIC 5.2. PATHFINDER-3.5 is based on a MINIMUF-3.5 algorithm and PATHFINDER-85 is based on the MINIMUF-85 algorithm.

code review

The listing for the general version of PATHFINDER is included at the end of this text. This will enable you to develop most hf analyses required. I have chosen to hard code the home station location and eliminate input error checking; items that could be added after the program is running. In the discussion to follow, the only reference to a program section is by its initial line number. A run which exercises all major sections of the program is included in **table 2.**

The declaration and initialization section starts at **fig. 1, line 10.** It sets up the constants and arrays needed, and collects the input required to run a simulation. The main menu selection follows at line **200.** The menu is multilevel on a priority basis. Each question is answered with one of the indicated option values. Caution: you can only list *after* a MUF simulation has been run. From this point all sections are

subroutines involved with program operation. The applications drivers are next: hourly MUF at 1000 (short path at 1010), radial MUF at 1100, gray-line at 1300 and bearing and distance at 1400. Next comes the MUF computation with the MUF setup at 2000, day and darkness critical frequency computations at 2100 and 2200 respectively, followed by the base MUF and FoF2 determination at 2300. The polar model begins at **line 2400** with the final point MUF resolution starting at 2600.

The next set of program blocks represents lower order support for the drivers. At **line 3000**, path bearing and distance are determined. The control point setup starts at 3100. Point latitude and longitude given a bearing and distance from a reference point are computed in the subroutines starting at 3300 and 3400, while the subroutine at 4000 determines the number and spacing of the control points and calculates the M-factor from the path information. **Line 5000** enters a routine to characterize the aspects of solar illumination of a point. Two math routines are next; the ARCCOS function at 6000 and a range limiting function at 6100. The "soft" output routines follow: gray-line at 7000, bearing and distance at 7100, and simulation base at 7200. The input routines are last: date at 8000, solar factors at 8200, and target location at 8300. The last line of the target routine starting at 8320 is used as a subroutine by the analysis drivers to assure correct target location definition. This is necessary because the radial MUF routine redefines the target longitude with each bearing increment.

Significant gaps have been intentionally left in the program line numbering sequence. This allows ample room for program expansion and makes program segmentation easier. All listings in this article are presented in Microsoft Extended BASIC-80 version 5.2 for a CP/M 2.2 operating system. This is a universal programming language that may have some features and syntax not shared with other dialects of BASIC. One problem may arise with the ON-GOTO/GOSUB constructs used in the menu; they may have to be replaced with a chain of IF-THEN statements for other systems. Please refer to the user manual of your BASIC language during conversion. This version of PATHFINDER has been submitted to the ARRL Program Exchange along with several conversions including one written in TURBO PASCAL™.*

experiences with PATHFINDER

Art Allen, KY1K, mentioned that there was a lot of activity on 20 meters to the western Pacific one morning in late June. PATHFINDER confirmed for Art that the mode was long path and that it also covered Japan and parts of UAO land. The short path MUF to those locations was at or below 8 MHz at the time while the long path MUF was well above 10 MHz.

K3RN, Bob Newkirk, spends a lot of time on the air at daybreak. I ran a gray-line summary for him last year using a version of PATHFINDER with access to a world latitude/longitude data base. Bob's country total is already high so it didn't net him any new ones but the projections were "just about right on" and gave him a couple of weeks of fun checking out my data.

In the week before Field Day 1987, I used PATHFINDER to track and characterize the MUF for W1KVI (Portland Amateur Wireless Association). I generated point-to-point reports for 15 paths between 500 and 2500 miles as well as radial reports for these distances at four-hour intervals. Trends suggested by these projections were as follows: 20 meters would be poor from 0400 through 1100 UTC, the West Coast would not be strong on 20 and propagation for that band would favor the 1300 to 1800 mile range; 15 meters also indicated some promise around noon in the 1800 to 2600 mile range. These projections were very close as indicated by contacts in our logs.

Success with the MINIMUF ionospheric models in PATHFINDER lies in the interpretation of all the factors involved. The MUF report is not 100 percent accurate: one must consider the absorption characteristics indicated by the K and A indicies; watch the path build up and decay over time; and consider the paths to adjacent areas in order to get a good feeling for what the computer is telling us. By providing the ability to run several types of analyses within one program, PATHFINDER can help determine the probability of working that new country.

summary

PATHFINDER is a general hf operating aid capable of providing MUF analysis modes as well as gray-line and bearing/distance reports. It uses MINIMUF-85 algorithms and has been optimized for both utility and speed. There is an elementary, menu-driven, top-level program allowing you to change input data, run, and report analysis at will without having to restart. By running several types of evaluations in the same session, you will gain a better appreciation for what is going on in the ionosphere.

Available publication space has required that the code for PATHFINDER presented in this article be rather spartan. In the future I hope to provide the code necessary to build and access a latitude/longitude data file as well as make use of the MOUT(x) array for simple graphical presentation of the simulation results.

I have had a lot of fun with this project and am more

*TURBO PASCAL is a registered trademark of Borland International, Inc., Scotts Valley, California.

INTERNATIONAL MONTHLY MAGAZINE BY AND FOR ACTIVE RADIOAMATEURS

Radiosporting

THIS IS IT! – FOR BIG GUNS & LITTLE PISTOLS

A magazine dedicated to quality and sportsmanship in amateur radio operating. Fresh, timely, practical and down to earth reading for little pistols and big guns. Written by the world's best in their fields: ON4UN, SMØAGD, LZ2CJ, VE3BMV, KH6BZF, DJ9ZB, ZS6BRZ, W1WY, N2AU, K7GCO, K4ZN, W4GF, VE3JTQ, WB4ZNH, WB9TBU, KQ2M, NS6X, W3FG, KA3B, K1PLR, N7CKD, VE3XN, ABØX, JE1CKA and others.

Includes DX News, QSL Info, 160m, 80m, 10m, 6m columns, DXpeditioning, Propagation, Awards, Contest rules and results, Traffic – Emergency, FCC News, New Products, Antennas, Technical news and articles, equipment reviews and modifications, computer programs, Radio Funnies, Club Life, RTTY, VHF/UHF, Mail Box, Classified Ads and much more in a magazine format with the speed of a bulletin.

RADIOSPORTING sponsors DX Century Award, Contest Hall of Fame and World Radio Championship contest.

"Your publication is superb! Keep it up!" Joe Reisert, W1JR

"Your W2PV articles are priceless. Your magazine is super!" Rush Drake, W7RM

"Let me congratulate you on a very impressive magazine. Just what I've been looking for as a DXer and Contester!" Dick Moen, N7RO

"RADIOSPORTING, once received, cannot be tossed aside until it is read from cover to cover. Then reviewed again and again." Chas Browning, W4PKA

Subscription rates: 1 year USA $18, Canada CDN$26, Overseas US$23; 2 years $33, $48, $42 respectively. Single issue $2. USA First Class Mail add $8/year, DX Air Mail add $15/year.

TRY US! SUBSCRIBE OR SEND $1 FOR YOUR SAMPLE COPY.

RADIOSPORTING Magazine
PO Box 282, Pine Brook, NJ 07058, USA ✓ 196

than satisfied with it. I wish to thank all those who contributed to PATHFINDER including: K6GKU for time and much effort in reviewing the manuscript and program, and K1ME for the use of his TNC in transfering the program to AJ1T for the Commodore conversion. Thank you and happy DXing.

references

1. Rose, R.B., "MINIMUF: A Simplified MUF Prediction Program for Microcomputers," *QST*, volume 66 (12), page 36-38, 1982.
2. Elwell, H.G., "Calculator-Aided Propagation Predictions," *ham radio*, April 1979, page 26.
3. Elwell, H.G., "360-degree MINIMUF Propagation Prediction," *ham radio*, February 1987, page 25.
4. Overbeck, W. and Steffen, J.A., "Computer Programs for Amateur Radio," Hayden Book Company, Hasbrouck Heights, New Jersey, 1984.
5. ibid.
6. Sailors, D.B., et al, "MINIMUF-85: An Improved HF MUF Prediction Algorithm," Naval Ocean Systems Center Technical Report 1121, July 1986.
7. Rose, R.B. and Martin, J.N., "MINIMUF-3.5, Improved Version of MINIMUF-3, A Simplified HF MUF Prediction Algorithm," Naval Ocean Systems Center Technical Document 201, October 1978.
8. Rose, R.B., "MINIMUF Revisited," Technical Correspondence, *QST*, volume 68 (3), 1984, page 46.
9. Hall J., "High Frequency Estimations for the Radio Amateur," *QST*, volume 56 (3), 1972, page 14.
10. Shallon, S.C., "MINIMUF for Polar Paths," Technical Correspondence, *QST*, volume 67 (10), 1983, page 48.

ham radio

NEW SUPER FAST C-64 LOGGING PROGRAM
from the Commodore Experts Riebstone Software.

Revolutionary new contest program for the C-64 computer designed and tested by active contesters. Can be used in CQWW, ARRL Sweeps, Field Day, ARRL DX Test or any other Contest. Can be used with ONE OR TWO DISKDRIVES. Superfast dupechecker with real time clock ON or OFF. 3,000 QSOs stored per band on your data disk. Special print and formatting routines plus much more. Easy-to-use and user friendly. Worth twice the price.

Just $39.95 plus $3.50 shipping and handling

Also available QSL CARD FILE DATA BASE.

Organize your QSLs on computer for fast and easy retrieval of information. Each file has 28 fields which can be filled in or edited at any time. Each data disk will accept 400 complete records. Includes special print routine.

Just $19.95 plus $3.50 shipping and handling.

BUY BOTH SPECIAL
Contest Logger @ $39.95 plus
QSL Data Base @ $19.95
Regular $59.90

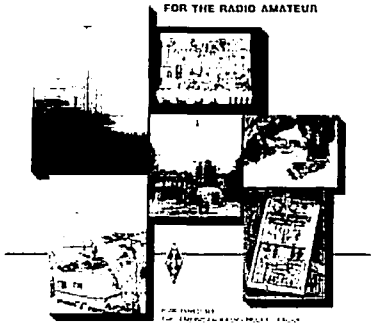
SPECIAL SALE PRICE JUST $49.90
Save $10! plus $3.50 shipping & handling

We accept VISA/MASTERCARD-PERSONAL CHECKS

RIEBSTONE SOFTWARE CO.
P.O. Box 13532
St. Louis, Missouri 63137

✓ 197

THE 1988 ARRL HANDBOOK
FOR THE RADIO AMATEUR



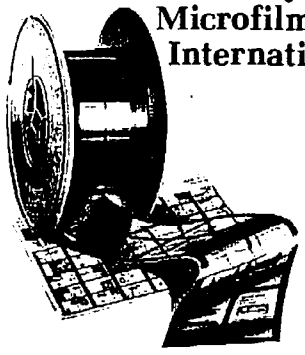
NEW EDITION

The 1988 ARRL Handbook For The Radio Amateur carries on the tradition of the previous editions by presenting 1200 pages of comprehensive information for the radio amateur, engineer, technician and student. Clothbound only. **$21** in the U.S., **$23** in Canada and elsewhere.

THE AMERICAN RADIO RELAY LEAGUE
225 MAIN STREET
NEWINGTON, CT 06111

✓ 198

This publication is available in microform from University Microfilms International.



Please send information about these titles:

Name _____
Company/Institution _____
Address _____
City _____
State _____ Zip _____
Phone ( ) _____

Call toll-free 800-521-3044. In Michigan, Alaska and Hawaii call collect 313-761-4700. Or mail inquiry to: University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106.



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

why not a two-element Yagi?

Many years ago my three-element 20-meter Yagi suffered severe damage in a furious wind storm. I was able to get the wreckage down before the winter weather set in, but the chance of getting the antenna repaired and back atop the tower were slim, considering the ominous weather reports. As a stop-gap measure, the beam was converted to a two-element array on a short boom which could quickly be carried to the top of the tower by a single person. This seemed a reasonable, short-term solution, so I took it.

I was pleased with the results achieved by the small beam. It worked so well that it was many months before the larger three-element beam replaced it.

Nevertheless, the two-element Yagi has faded into relative obscurity. Popular in the fifties when few commercial beams were available, it disappeared with the advent of manufactured antennas. Lately there has been renewed interest in the little antenna; more and more newcomers to the 10-meter band are erecting two-element beams and having excellent results with them. I hit the band a few months ago with a compact two-element antenna and was flooded with questions about it. Here is the story of this small, inexpensive Yagi with a big punch!

the two-element Yagi for 10 meters

As compared with a three-element beam, the two-element Yagi is lighter, smaller, has less wind resistance, and can be built easily and inexpensively. The antenna has a single director spaced 0.1 wavelength in front of the driven element and a theoretical gain of about 5 dB over a dipole with a front-to-back ratio at the design frequency of about 13 dB.

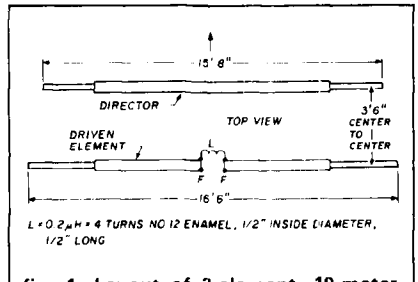


fig. 1. Layout of 2-element, 10-meter Yagi. Coil L is placed across feedpoint F-F to achieve good match. Wind coax transmission line into choke coil (4 turns, 8" diameter) at feedpoint.

In comparison, a three-element Yagi on a 0.25 wavelength boom with equal spacing between elements has a theoretical gain of about 7.1 dB over a dipole and a front-to-back ratio at the design frequency of about 23 dB.

The two-element Yagi has about 2 dB less gain than the three-element antenna, and has a front-to-back ratio about 10 dB poorer. However, the boom length of the two-element beam is only 40 percent of the larger array. This is important in areas with high winds. Some Amateurs, particularly those living in the Midwest, require as much front-to-back ratio as they can get because of interference from both the East and the West. In other areas of the country, the Amateur can opt for the smaller array without losing very much in antenna performance.

building a two-element 10-meter Yagi

Assembly information for a compact, 10-meter Yagi is shown in **fig. 1**. The design frequency is 28.4 MHz, making the antenna suitable for CW, Novice, and regular Amateur service from 28.0 to about 28.8 MHz. The feedpoint resistance of the antenna

is about 17 ohms. Element spacing, center-to-center, is 3 feet 6 inches.

Raise the feedpoint impedance to 50 ohms by shortening the driven element slightly to make it capacitively reactive at the design frequency, and place a small inductor across the feedpoint. This arrangement comprises a simple impedance step-up L-network. Wind the coax transmission line into an rf choke at the antenna feedpoint to preserve feedpoint balance and decrease the chance of rf getting into the shack.

Array construction is greatly simplified by using a wood boom and wood brackets for element support (**fig. 2**). My boom is made of a length of well-dried, two-by-two lumber that was sanded and given two coats of marine varnish. The element supports are 16-by 3-inch lengths of finished wood (5/8-inch thick), painted with varnish and fixed to the boom with glue and small nails or screws.

Fasten the boom to the mast with a gusset plate made of 5/8-inch thick plywood. Because this material can disintegrate quickly unless it is protected from weathering, seal the edges with two coats of wood preservative and give the whole plate two coats of outdoor house paint. Fasten the boom to the plate, and the plate to the mast, with pairs of galvanized U-bolts. Use washers and lock washers on all bolts to make a rigid joint.

Attach the elements to the wood crossarms with either U-bolts or homemade clamps made of scrap aluminum. (I had no luck finding U-bolts that matched the diameter of the element; however, once the beam was up in the air the correct size U-bolts magically showed up at several hardware stores.)

assembling the elements

The elements are made of three sections of commercial grade 6061 aluminum tubing. Use a 12-foot length for the center section and short, telescoping sections of tubing for the tips. The center section of the element is 5/8-inch diameter tubing, with a wall thickness of 0.058 inch so that the 1/2-inch tubing will easily telescope within it. (Any diameter tubing will fit into the next larger size if the larger size has a 0.058-inch wall thickness.) The end sections are 1/2-inch diameter tubing with 0.035-inch thick walls. The tips have thin walls to decrease weight.

To lock the tubes in position, use a hacksaw to cut a narrow slot about a foot long in the end of the center tube, through both walls, on a line with the center axis of the tube. Remove all burrs from both the inside and outside walls; then sand and clean the tips to lessen the possibility of seizure after the tubes are telescoped. Make the slots wide enough so that when pressure from a hose clamp is put on the walls of the outer tube, the inner tube is held firmly in place.

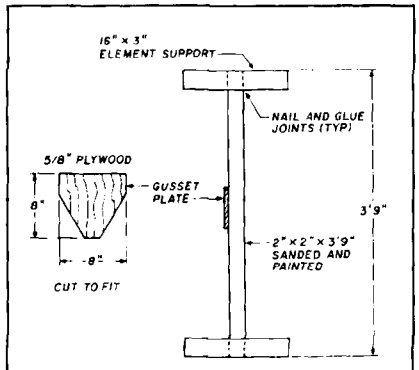


fig. 2. Boom details for 10-meter beam.

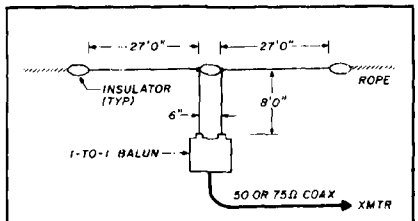


fig. 3. 7- and 21-MHz broadside antenna.

Smear a small amount of anti-oxidizing compound over the end of the smaller tube to prevent corrosion and oxidation of the joint between the tubes. This lubricant is commonly used in industrial power installations and sold by large electrical supply houses. Some trade names are Penetrox™, Cual-Aid™, and Ox-Guard™. The compound is a good electrical conductor and ensures a trouble-free joint. A small tube of the paste is sufficient for three or four antenna arrays.

Split the driven element at the center to provide a feedpoint. Separation between the sections is about an inch. To preserve alignment, force the element sections on a short wooden dowel that has been given two coats of varnish for weather protection. Drill the element ends for bolts and nuts to provide a connection point for the feedline.

Bolt the matching coil across the feedpoint like the coaxial line. Prepare the line by skinning the outer insulation back a few inches. Unbraid the outer conductor by using a small nail to separate the wires. Twist the wires into a pigtail and place a solder lug on the end of the tail. Place a second lug on the center conductor of the line. Waterproof the end of the line by covering it with Coax-Seal™ or wrapping it securely with vinyl tape. Make sure that water cannot enter the end of the line — it would quickly corrode the conductors.

Finally, wind the coax line into an rf choke just before it attaches to the driven element. Six turns of line wound into a coil whose diameter is twelve times the diameter of the coax will suffice. Hold the coil in place with vinyl tape.

erecting the beam

A heavy-duty TV rotator turns the beam. Make sure the one you use has a lock so that the antenna will not "windmill" when the rotor power is off. Mount the antenna to a short vertical pipe that fits the top section of the rotor.

The antenna can be as low as 16 feet above ground for good results around the United States. You can mount it relatively inconspicuously just above the roof of a one-story dwelling. A height of 25 to 40 feet is recommended for better results. When building and testing the beam I had it mount-

QSO PRO
is on the
MOVE!
SEE US AT DAYTON BOOTH 447
An Easy To Use Logbook Program For Your MS-DOS® Compatible Computer
★ Complete Cursor Control ★ Room to store complete adress information ★ A Real-Time Log ★ Total QSL's by state ★ 900 QSO's on floppy, hard disk limited by space available
$39.95*
*Ohio residents must add 5% sales tax
U.S. FUNDS ONLY
MORLAN SOFTWARE
P.O. Box 2400
East Liverpool, Ohio 43920-0400
101

Texas Radio
BUGCATCHER MOBILE HF ANTENNA
NEW IMPROVED MODELS!
Stainless Whip
8-BAND COVERAGE - All Amateur, MARS, and CAP frequencies from 10 to 80 meters!
BANDSWITCHING - Switches instantly to pre-tuned frequencies on any band!
Stainless Spring
HIGH-Q RESONATOR - High-Q air inductor provides maximum efficiency on all bands!
Bandswitching High-Q Resonator
FUNCTIONAL DESIGN - Provides low wind loading, easier tuning, and more pleasing appearance! Rugged construction for long life and reliability. New fold-over feature!
500 WATT CAPACITY - Conservative rating!
COMPLETE ANTENNA - READY TO MOUNT
PRICE $74.95
1000 WATT MODEL AVAILABLE - $84.95
Stainless Base Section
Add 5% for shipping in lower 48.
SASE for Product info.
TEXAS RADIO PRODUCTS
5 East Upshaw Temple, Texas 76501
(817) 771-1188
102

AMATEUR RADIO MAIL LISTS
Sell-stick 1x3 labels
*** NEWLY LICENCED HAMS ***
*** ALL NEW UPGRADES ***
*** UPDATED EACH WEEK ***
Total List = 462,728 (ZIP sorted)
Price is 2.5 cents each (4-up Cheshire)
BUCKMASTER PUBLISHING
Mineral, Virginia 23117
703:894-5777
103

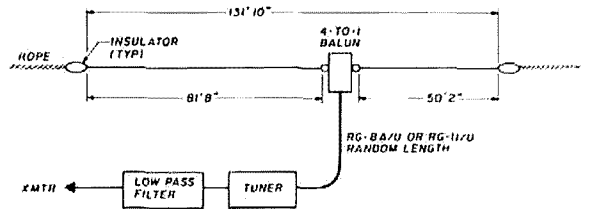


fig. 4. The "Carolina Windom" antenna works 80-10 with tuner. WA4LVB recommends that the antenna be 35 feet or higher above ground.



fig. 5. National Bureau of Standards forecast for sunspot cycle 22 based on data as of August 1987.

ed atop a 6-foot step ladder. Even at that low height I was able to make many contacts nationwide with good reports, so don't let height restrictions stop you from considering this project.

adjusting the beam

The beam as described probably won't require any adjustment. It provides a bandwidth of about 800 kHz between the 2:1 SWR points. However, any antenna is sensitive to the immediate environment and to the height above ground. Check the SWR from 28.0 to 29.0 MHz and make a chart of SWR reading versus frequency. It should be a smooth curve, with a minimum SWR figure near the design frequency of 28.4 MHz. If the SWR at the design frequency seems too high, adjust the spacing of the matching coil turns slightly, or increase or decrease the number of turns. The length of the driven element can be adjusted to bring the minimum SWR point to the desired frequency, but in the majority of cases these adjustments will not be required.

compact 7- and 21-MHz antenna

This wire antenna, designed by G3TKN, fits into a 55-foot span and works on two bands. It is a 7-MHz dipole with the center section folded up to form a simple matching stub on 21 MHz, where the antenna operates as a two-element collinear array providing about 3 dB power gain. Antenna dimensions are given in fig. 3.

The center stub is made of two No. 14 enamel-coated wires with a 6-inch separation. Three spreaders are required and can be made from plastic rod or 3/8-inch diameter wooden dowel. Give the wood a weatherproof coat of varnish. Pass the wire through holes drilled in the ends of the spreaders. Hold it in place by winding short lengths of No. 22 wire around the dowel and the stub wire passing through it.

Feed the antenna with a 1:1 coax balun and a coax feedline. Optimize feedline SWR on 21 MHz by varying the length of the stub an inch or two at a time. The antenna performs well when elevated 30 feet, or higher. On 40 meters the pattern is that of the conventional dipole; on 15 meters it is also bidirectional but with sharper lobes.

the "Carolina" windom antenna

This antenna, popularized by W8GZ* in the early twenties, is still with us in various forms. The latest idea was sent to me by Edgar Lambert, WA4LVB. It seems the idea was conceived by W4UEB, WY4R and WA4LVB. The antenna is shown in **fig. 4**. The flat top is cut for 3550 kHz and is off-center fed with a 4:1 balun and a coax line. Since Edgar told me about it, I have heard several of these antennas on 20 meters and they seem to poke out a good signal. Edgar says it's a good approximation of the mythical "all-band" antenna. Maybe so. Why don't you try it out and send me your results?

sunspot cycle 22 coming up!

At last! Old sunspot cycle 21 ended about September, 1987. There's no doubt about it. Ten meters has been "hot" since the fall of 1987. Happy days are here again!

While 10, 12, and 15 may be "flat" during the summer months, there will be plenty of sporadic-E short skip to liven up the bands. They will come alive with a bang in mid-fall!

So what are the prospects for the next sunspot cycle: cycle 22? The Space Environmental Services Center of the National Bureau of Standards predicts the next cycle will peak in 1990 through 1992 with a plateau of about 110. The general prediction for cycle 22 is shown in **fig. 5**. It seems as if 10 meters will be a good DX band until at least 1997! That's nine years of good DX conditions ahead for Amateur Radio. I'll drink to that!

ham radio

*ham radio regrets that L. G. Windom, W8GZ, died on February 1, 1988.

AR501
BACK TO BASICS...
But far more advanced...



Model AR501 Telegraph Terminal
$229.00
(California res. add $13.74 tax.)

Visa and MasterCard orders are welcomed. Price includes shipping & handling. Purchase orders accepted from Government agencies

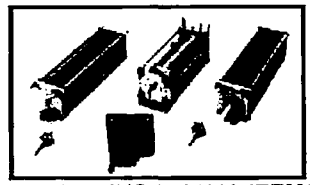
✓ 106

AR-501 covered by One Year Limited Warranty. Extended warranty service available at the following rates:
$25.00 – 3 Years $15.00 – 2 Years

AR501 is a compact triple mode CW terminal in a small package (4.5" x 6.25"x 2.25") but a powerful gear to practice and play with. As a CW decoder, it detects morse code between 5 to 30 WPM. **For practice?,** it activates and displays the code. **More?,** it operates as an electronic keyer both standard and iambic. **More yet?,** How about a print-out function? The **AR501** does just that. We offer a stand alone thermal printer as an option.

ACE communications, inc. TOLL FREE 1-800-523-6366
22511 Aspan St . Lake Forest, CA 92630-6321 (714) 581-4900 • Telex 29-7385 • Fax (714) 768-4410

1500 + WATT TRANSMATCH KIT $169.95



BASIC KIT: INDIVIDUAL ITEMS
1 - rotary inductor 28μh..... $59.00
2 - 6:1 ball drives.....$9.00 ea.
1 - 0-100 turns counter.....$65 75
2 - variable capacitors
25-245 pf 4500 v.....$44.00 ea.

OPTIONS—
enclosure (pictured in Sept. 86 CQ).$64.00
4:1 balun kit.....$22.50

OTHER KITS
Article Reprints (refundable).....$1.50
G3RUH, PSK Packet Modem, Satl./Terrestrial$99.00
PC Board for above only, delivered.....$27.99
Ten-Tec Designer Cabinet for above.....$12.00
K9CW Memory Contest Keyer.....$109.00
Yaesu FRG-9600, .1 to 60 MHz Converter....$94.95
20m CW, 15w Transceiver (H.R. 6/87).....$159.95
50W 75M SSB XCVR.....$199.95

Factory Wired
Nel-Tech DVK-100A (New Model).....$269.00
B & W PT-2500A Amp.....$1,670.00
B & W VS1500A Tuner $388.00
Amp Supply/Ameritron Linears.....CALL

Shipping Extra Unless Noted
Catalog $1.00
RADIOKIT • P.O. Box 973-H
Pelham, NH 03076 • (603) 635-2235
dials, terminals, chassis, ceramic standoffs, hardware, toroids, amp components, B&W coil stock, etc.

✓ 108

ATV CONVERTERS • HF LINEAR AMPLIFIERS



AMATEUR TELEVISION CONVERTERS
ATV2 420–450 $ 44.95 Kit
ATV3 420–450 $ 49.95 Kit
ATV4 902–928 $ 59.95 Kit

AUDIO SQUELCH CONTROL for ATV
SIL $ 39.95 Kit

2 METER VHF AMPLIFIERS
25 Watt Model 325A $ 79.95 Kit
75 Watt Model 875A $119.95 Kit
Available in kit form or wired and tested

HF AMPLIFIERS per MOTOROLA BULLETINS
Complete Parts List for HF Amplifiers Described in the MOTOROLA Bulletins
AN758 – 300 Watts E0863 – 140 Watts
AN762 – 140 Watts E0274 – 300 Watts
AN779 – 25 Watts E0104 – 600 Watts

POWER SPLITTERS and COMBINERS 2–30MHz
600 Watt 2–Port $ 59.95
1200 Watt 4–Port $ 69.95

BROADBAND TRANSFORMERS per MOTOROLA Engineering Bulletins
RF400–1 (2.0 uH @ 1.0MHz) $ 3.95
RF600–1 (4.0 uH @ 1.0MHz) $ 4.45
RF800–1 (4.2 uH @ 1.0MHz) $ 4.95
RF1000–1 (8.0 uH @ 1.0MHz $ 5.95
For detailed information and prices, call or write for our free catalog

FERROXCUBE DEVICES
VK200–20/4B RF Choke $ 1.20
56–590–65–3B Ferrite Bead $ .20

HEAT SINK MATERIAL
Model 99 Heat Sink(6.5x3.2x1.6) $ 20.00
CH5–6 Copper Spreader(6x6x1/4) $ 20.00
Add $2.00 additional shipping

We also stock Hard–to–Find parts
CHIP CAPACITORS
METALCLAD MICA CAPACITORS
SEMICONDUCTORS
RF POWER TRANSISTORS
RF CHOKES
MINI–CIRCUIT MIXERS
SDL–1 $ 6.50
SDL–1X $ 7.95
ARCO TRIMMER CAPACITORS

Add $ 2.00 for shipping and handling

VISA CCI Communication Concepts Inc. master charge
121 Brown Street • Dayton,Ohio 45402 • (513) 220–0677

✓ 112

the Quad antenna: part 1, general concepts

A comprehensive study of this popular antenna

This is the first in a series of articles on the Quad antenna family. In this series I will attempt to:

- clarify the concepts of Quad family antenna design.
- set forth Quad theory to the extent needed for practical design.
- provide easily used design data for a range of practical designs, medium frequency (mf) to very high frequency (VHF).
- provide data on practical construction to eliminate current physical weakness problems.

Included are:

- concepts of the loop family
- circular loops; octagonal loops
- circular loop arrays; octagonal arrays
- the Quad loop family
- arrays of Quad loops
- the triangular loop family
- triangular loop arrays
- ground effects on loops and arrays
- multifrequency loop designs
- other loop designs
- loops and array construction techniques

There will be several installments on the elements of theory and design data, each dealing with a single member of the Quad family.

Quad versus Yagi

The Yagi is the most popular type of Amateur directive antenna. Surveys on the hf bands show that over half of all stations use some form of Yagi. Three-element triband designs with traps for band isolation are the most common.

The Quad, second in popularity, is usually a two-element design using the square configuration. Many are single band, others are two or three single-band antennas on a common boom. True multiband Quad elements have been designed, but are rarely used.

The lower portions of the hf band tend to favor delta or triangular loop Quads that need only a single high support. The circular loop is popular on VHF. But total usage is about one-fourth that of the Yagi — some 12 to 15 percent of all installations (this includes all types of antennas, not just Yagis). Commercial use of Quads is limited and they are relatively low sales items on the Amateur market.

The pros and cons of using a Quad are often debated. The most common reason given for using a Quad is that it is a good directive antenna which can be built from locally available materials. It's fun to experiment with and has a reputation for good performance at low height. Long-time Quad users seem to stay with the design because they like the performance.

Three reasons usually given for not using a Quad are: susceptibility to damage during high winds, lack of space, and lack of design data for the high-performance types. In actuality, these are weak reasons for rejecting this antenna. First, the wind damage factor can be reduced by solving aerodynamic and mechanical design problems. Second, for a given gain, the Quad can have a smaller turning radius than a Yagi. This allows it to fit into smaller places, and makes it easier to obtain gain at lower frequencies. Finally, there is an enormous amount of literature covering all elements of Quad theory, design, performance, and construction.

Unfortunately, Quad literature tends to be fragmented. The theory and most precise design and performance data are written by scientists and engineers; the practical construction data appears in Amateur

By R.P. Haviland, W4MB, 1035 Green Acres Circle North, Daytona Beach, Florida 32019

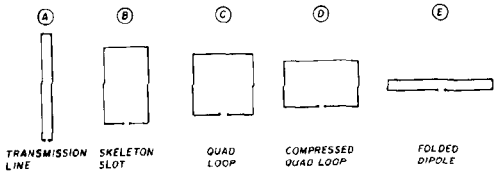


fig. 1. The square (4-sided) Quad family, conceptually formed by separating the sides of a two-wire open transmission line shorted at the far end. As a first approximation, all members behave as a transmission line.

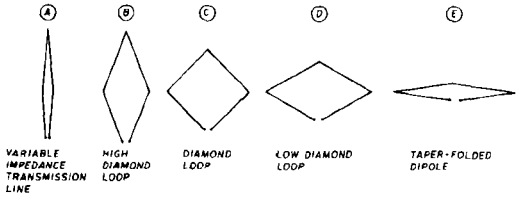


fig. 2. The diamond Quad family, formed by changing the separation of transmission line sides at the midpoint. Again, all members behave as a transmission line. Properties are very close to those of the square Quad family.

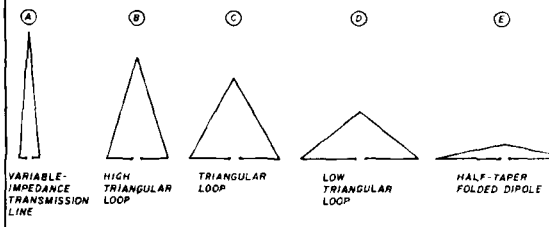


fig. 3. Triangular loop family, formed by changing the transmission line spacing at the feed point. Transmission line behaviour indicates that the performance will be similar to the square and diamond loops.

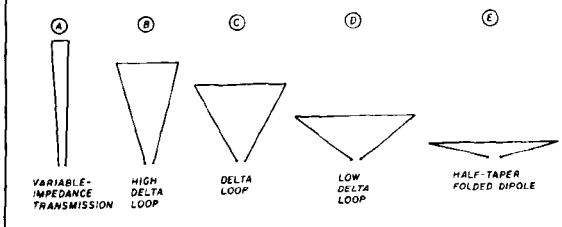


fig. 4. Triangular or the delta-loop family. Transmission-line spacing change is at the far end of the line.

Radio publications. The scientific data are hard to use in a practical sense because computers are needed to derive useful design values.

shapes of the Quad families

One of the easiest ways to approach the Quad concept is to start with a length of open-wire transmission line, shorted at one end and with a generator at the other, as shown at A in **fig. 1**. If the spacing between the sides of the line is progressively increased, the shapes of B to E successively develop. These shapes are representative of the rectangular Quad family. From A to E, the shapes are:

A shorted line
B skeleton slot
C Quad loop
D compressed Quad
E folded dipole

Instead of keeping the sides of the figures parallel, we could choose the midpoint of the sides as the point of inflection and create a second family with diamond-shaped members (**fig. 2** A to E). The center shape is the only one commonly named, the diamond Quad.

When three points of inflection are used instead of four, the result is two families of triangles as shown in **fig. 3**, A to E, and **fig. 4**, A to E. The center triangles in each figure are generally called delta loops, and are distinguished by whether they are fed at an apex or the midpoint of a side.

You can use more than four points of inflection. At the upper limit, the sides become smooth curves — the ellipses and circle of **fig. 5**, A to E. At the extremes, A is still a shorted transmission line section and E is a folded dipole.

It is not required that the shapes remain symmetrical, that the conductor always be along the perimeter of the figure, or that no part of the figure be re-entrant. Three possible shapes are shown in **fig. 6**. A is an acute triangle, B is a bent-side or bat-wing Quad, and C is a "line shortened" Quad.

The element need not be confined to a plane. The G4ZU Birdcage and the Swiss Quad, examples of non-planar elements, are basically variations of the bat-wing element of **fig. 6** with the apex of the bent element pulled out at right angles to the paper.

Finally, simple and symmetrical shapes are not the only ones that may be used. **Figure 7** shows some other designs: A uses a transmission-line section to reduce size, and B and C use a form of capacitive hat for the same purpose. D uses a form of open-wire feed to give choice of polarization.

conceptual approach to Quad performance

The end points of the major Quad families have well-known characteristics, providing a basis for a concep-

tual approach to Quad performance. Let's start by looking at the shorted transmission line.

First, suppose the generator frequency for the line of **fig. 1A** is varied. At very low frequencies, any practical line is basically a short circuit and has little effect. The resistive component of impedance is small, essentially zero. The reactance is also small, and inductive.

Both resistance and inductive reactance increase with frequency. This increase continues until the line becomes one-quarter wave long. At the frequency where this occurs, the input impedance is very high, and purely resistive. The line acts as a parallel resonant circuit. This is also known as the first resonance point.

For still higher frequencies, the resistance decreases, and the reactance decreases from its infinite value, but is now capacitive. When the line is one-half wave long, the reactance again becomes zero. The input resistance would be zero for a lossless line. This is the first series-resonance point. At slightly higher frequencies, the resistance and reactance increase, and the reactance is (again) inductive.

The pattern of alternating low and high impedance, and inductive and capacitive reactance, repeats at increasing frequencies. **Figure 8** shows the pattern with the peaks and nulls marking additional resonances.

At the other (shape) extreme is the folded dipole of **fig. 1E**. At low frequencies, its input resistance is very low. Its reactance is high, and capacitive. The antenna looks like a small capacitor in series with a small resistor.

Reactance decreases and resistance increases with increasing frequency, until the antenna is somewhat less than a half wavelength overall. At this point the reactance is zero, and the resistance is very nearly 300 ohms, just four times the resistance of a resonant single-wire antenna. This is the first resonance point.

At still higher frequencies, the resistance continues to increase. The reactance also increases, but is inductive in sign. With the antenna just less than a full wave overall, reactance again becomes zero, and impedance is very high.

This pattern also repeats, at close to each half wavelength. The points of low impedance and zero reactance mark the second, third, etc. current-feed resonances, and the high impedance points to the voltage-feed resonances.

frequency/size/pattern relationship

Before going on, let's consider the effect that changing frequency (or size) has on the radiation pattern.

At frequencies small compared to first resonance, the current on all parts of the wire will be nearly equal in magnitude and phase, as indicated for the loop in **fig. 9**. For a point on the loop axis, at right angles to the plane of the paper, the field contributions of the eight points of current shown appear as in the small vector diagram, and add up to zero. In the plane of the paper, the components from the near and far side of the loop have an out-of-phase component, because of the time required for a radio wave to travel across the loop. A doughnut-shaped pattern results. The hole axis is at right angles to the plane of the paper.

These very small loops will radiate well, but will be difficult to feed because they have very low resistance — not much more than the conductor itself. Loss in the matching system will be high.

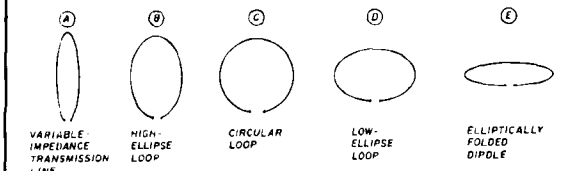


fig. 5. Circular-loop family, formed by smoothly changing the transmission line spacing. For a given length of conductor, the circle has the greatest area, and will show higher gain than the square. (For the same given perimeter, the area of a circle is 27 percent greater than that of a square.-Ed.) However, the figures with greater separation of the current maxima can show still higher gain: this is true for all loops.

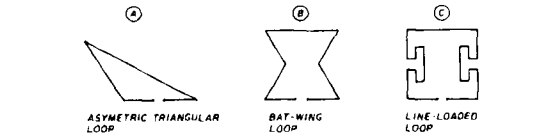


fig. 6. Examples of other possible shapes. In each case, the area in the figure is less than that for a corresponding simple symmetric member. This reduces gain below maximum (possible), but allows attainment of some other objective, such as small size or use of a given support.

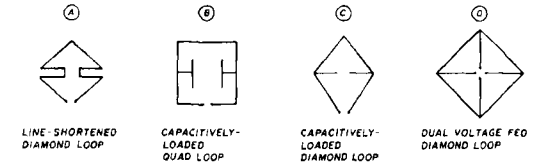


fig. 7. More examples of special shapes, all using some form of loading to reduce antenna size. Line sections can be replaced by inductors, and the capacitive sections by actual capacitors. The fourth shape uses the capacitive lines as the feed point, to allow horizontal or vertical polarization.

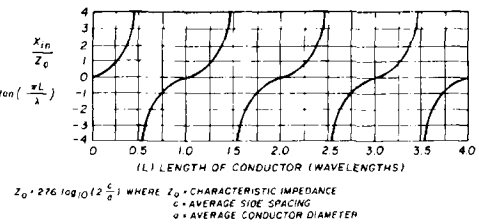


fig. 8. Generalized terminal reactance of a two-wire transmission line. The characteristic impedance is determined by wire size and spacing. From the standard formula, $Z_0 = 276 \log (2\frac{c}{a})$, c being the separation and a the wire diameter. Use the average separation for nonparallel-sided lines. Lacking other data, use this curve to give (approximately) the feed-point reactance for any member of the Quad family of loops.

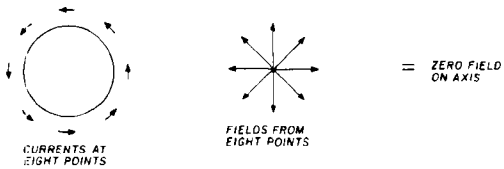


fig. 9. Vector field pattern of small loop, showing that the fields from individual wire segments cancel for on-axis radiation. The resultant field is doughnut shaped.

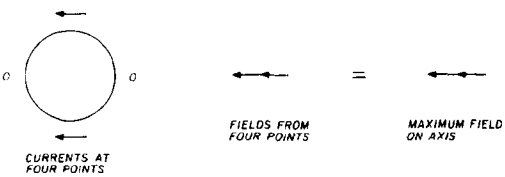


fig. 10. Vector field pattern for a one-wavelength loop. Components from the loop top and bottom add to form a major lobe on axis. The components at 45 degrees do not completely cancel, so there is a small doughnut pattern of vertically polarized radiation.

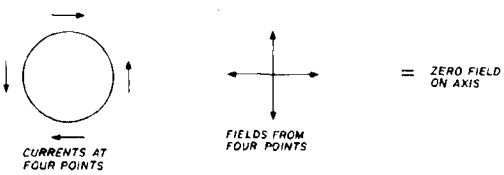


fig. 11. Vector-field pattern for a two-wavelength loop. Components on axis cancel, but add to form a double cone-shaped pattern. Cancellation of on-axis radiation occurs for wire lengths of three or more integral wavelengths also.

At frequencies close to first resonance, maximum current will occur at the feedpoint and half-way around the loop from it, as shown in **fig. 10**. The major field components from the upper and lower parts of the loop, on axis and at right angles to plane of the paper, are now in phase. In the plane of the paper, the components on the line of maximum current are out of phase. Maximum radiation is at right angles to the loop, and is horizontally polarized.

There are small components of current on the vertical parts of the loop. These are equal and opposite in phase and form a vertically polarized pattern. Most Quad analyses neglect this component, since it is much smaller than the main lobe. Its practical importance is not clear, but it may be responsible for creating the reputation of the Quad as a good performer at low heights and under marginal conditions.

For frequencies close to second resonance, maximum currents occur at each one-quarter point around the loop (**fig. 11**). Because currents on opposite sides are equal but opposite in phase, there is no net radiation on the loop axis. Maximum radiation occurs in the plane of the paper, with lobes of 90 degrees each. This is the general pattern for all resonances higher than the first, with the number of lobes equal to twice the order of the resonance. The pattern is the same for all simple shapes.

The considerations above indicate that the primary area of interest for the Quad family of **figs. 1** through **6** will be at or near first resonance, where the lobe structure is simple and on the axis of symmetry. For all of these shapes, the total conductor length is very close to one wavelength.

Quads with conductor lengths of two or more wavelengths don't have useful radiation patterns at right angles to the loop plane. One exception occurs if the basic transmission line is open circuited (**fig. 12**). The first, or serial, resonance point isn't too useful. The next (or parallel) one gives a simple lobe structure on the axis of the loop, which is useful in itself or as a switched open/shorted two-frequency loop. This was the basis of the now rarely used bi-square beam.

drive resistance relationship

The input resistance of a shorted one-half wave transmission line is almost zero (see discussion referring to **fig. 1**). For the folded dipole, the drive resistance is about 300 ohms. Considering that the currents in two wire segments interact less the further they are apart, we expect the input resistance of the intermediate shapes to fall between these limits. For the shapes designated as C, the input resistance should be near 150 ohms. The resistance will be lower

for the skeleton slot, or B types, and higher for the squashed *D* types. The exact pattern of variation must be worked out.

drive reactance and resonance relationship

Antenna resonance is defined by zero input reactance. All of the shape variations will have a specific point or points of resonance, and we can't expect them to be independent of conductor shape. For a shorted, air-insulated line, resonance will be very close to the physical half-wavelength point. The resonant frequency of a folded dipole will be some 5 percent lower. Because we don't know the current change due to variations in the separation of current points, we must determine the effect of changing shapes.

The magnitude of reactance change in moving away from resonance involves cosine functions. For small deviations from resonance, it is reasonable to expect that the reactance can be approximated by a simple linear function. The reactance, then, can be specified by two values — the frequency of resonance and the slope of the reactance curve. We must see if an additional simple function for shape can be developed.

gain relations near resonance

We can look at the gain from two viewpoints. The first is based on element separation. The gain of the shorted line section is zero, because the radiating section is approximately zero length. As we move toward other shapes, the radiating length increases, but the spacing between the two high-current sections decreases. As the shape approaches that of the skeleton slot, there will be two well-separated high-current sections of reasonable length. The gain should approach twice that of a simple dipole.

At the other extreme, the gain of the folded dipole is the same as a simple dipole. Thus, we expect a gain decrease when going from the very tall, narrow slot toward the dipole. Overall, the gain should increase slowly as the sides of the dipole are pulled apart, reaching a maximum at some separation, and then falling to zero gain. However, without some other guidance, we cannot state the gain of intermediate shapes.

A second way of looking at this gain variation is from the view of the effective area. Considering just the high-current part, the area measured in average amperes times electrical degrees of length will be nearly zero for the shorted line, unity on a per unit scale for the folded dipole, and basically two for the shapes (C). Thus we expect the gain of an optimum member of the Quad family to approach 3 dB above an isotropic. The circular loop should have the best gain, the rectangular one slightly lower, and the delta loop lower still. However, all nearly symmetrical shapes should show some gain with respect to a dipole.

Further consideration of the same area indicates that the gain of the resonant open-circuited (two wavelength) square should approach 6 dB above an isotropic at parallel resonance. We would expect many of the odd and re-entrant shapes to have gain, but the ones with small area will show a loss compared to a dipole.

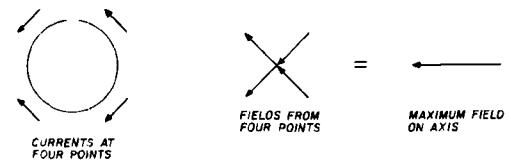


fig. 12. Vector field pattern for a two-wavelength loop formed from an open transmission line. The components add to produce an on-axis lobe. This lobe exists for longer wires also, but there are also added lobes.

Quad elements in beams

Any of the above shapes can be used in either a driven or parasitic beam. One way of looking at such beams is to assume that the radiation effect of each element is the same as if it comes from a point source located at the center of electrical symmetry of the element. This leads to the concept of pattern multiplication, where the overall pattern is the product of the element pattern and an array pattern, as determined by the relative spacing, current, and phase.

Because array patterns are well known (and quite simple in many cases), beam patterns will be easy to develop when the element patterns are worked out. There is, however, a corollary to this. Any unusual benefit from the Quad family will have to come from the elements themselves and not from the fact that they are assembled into an array.

In this simplified consideration, some gain above a dipole has appeared. It is expected that a Quad array can be shorter than an array of dipoles (Yagi) and still achieve the same gain. Although the vertical height is much greater, the horizontal span and the turning radius are less. For a given gain, Quads require less space.

neglected factors

A number of implicit assumptions were made in the preceding paragraphs. One is that the conductor has no loss, and is very thin. Currents were assumed to be sinusoidal. Small pattern factors, like the lobes in the plane of the elements, were ignored. These are important in a detailed analysis, but should represent only variations from simply derived values and not major changes.

Part 2 will cover the theory of circular elements and the beams constructed from them.

ham radio

short circuits

SM6CPI November 1987

In fig. 1 of SM6CPI's November, 1987 article, "A CAT Control System for the Yaesu FT-757GX," you may like to make one or two changes in line 4107. The first is related to the word format and the second should is only for C-64 machines made for the NTSC TV system, which have a slightly higher clock frequency than the PAL versions available in Europe. After the changes the first part of the line should read:

4107 DATA 195,255,96,128,0,6,0, 0,206,.....

You should also change the check sum (22360) in line 10020 correspondingly: to 22492 in the NTSC version or 22488 for a PAL machine. Neither of the two data seems to be critical in the present application, but they may create some confusion if you want to use the subroutines in other programs.

K7NH December 1987

In the article, "A Simple rotor interface board for the C-64 and the VIC-20," by Neil Hill, K7NH in the December 1987 issue three corrections to the diagram reproduced on page 18 are required:

Four jumpers are indicated but only the first three (counting from the left) should be used.

The change you need to make is a tricky one, so work carefully. Instead of connecting the jumpers to the land above (as shown in the diagram) connect all three to the land immediately to the right of their present (top) connections (in all three cases). If you haven't already, *do not* install the fourth or right most jumper. If you have, remove it. If you can't visualize the changes, send for our simple sketch.

N6GN February 1988

Some omissions and errors crept into Part 1 of "Designing a Station for the Microwave Bands" in the February 1988 issue.

On page 52, although many parts had labeled values in **fig. 4**, the material list was not included. It is as follows:
R42/45 and C32/33 are from **table 6** or calculated as shown in text,
U1,2,6 are 1/3 10116 ECL Line Receiver,
The extra gain of U2 is required when using harmonic downconverters,
U3,4 are OP07, 741 or similar opamp,
U5 is 12040 ECL Phase/Frequency Detector.
Jumpers on U5 pins 6 and 9 are connected as follows:

f_{RFH} relative to f_{POF}*	oscillator tuning sense (MHz/volt)	
Below	+	–
Above	–	+
*f_{RFH}	PLL downconverter reference frequency	
f_{POF}	Phaselocked oscillator frequency	

In the schematic, **fig. 4**, U4 has its inverting and non-inverting inputs shown reversed. The same circuitry is shown correctly in **fig. 6**.
Resistors may be 5 percent tolerance or better.
Similarly for **fig. 5** on page 58 the material list should be:
CR1 is Motorola BB105 UHF TV tuning varactor or similar,
L3 is 4-1/4 turns No. 28 on 5/32 inch form with adjustable core 180 nH nominal,
U7 is 1/3 of 10116 ECL Triple Line Receiver,
U8 is 10138 bi-quinary ECL divider,
Y1 is 100 MHz 5th overtone series resonant crystal.

The values for R42/45 in **table 2**, page 60, should be 25k ohms and 1.1 K ohms not 25 and 1.1 ohms as shown. Some omissions from **table 1**, page 44, will be included in a later part of the series.

editor

2x4Z BASE REPEATER ANTENNA

THE HIGHEST GAIN DUAL BAND BASE/REPEATER ANTENNA

HIGH POWER 200 WATTS

CENTER FREQUENCY
146.500 MHz
446.500 MHz

GAIN:
VHF - 8.2dB
UHF - 11.5dB
VSWR - 1.-1.2 or less

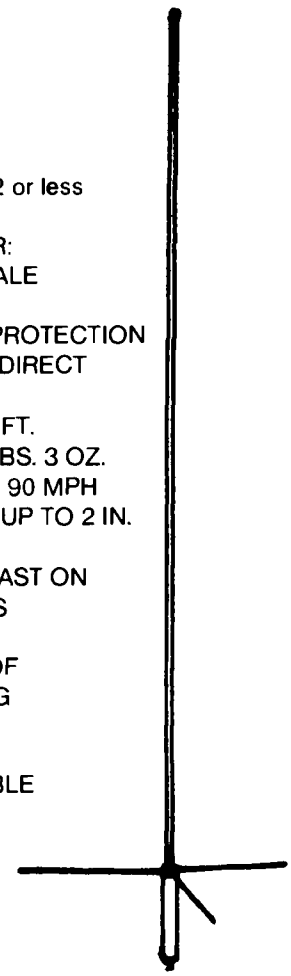
CONNECTOR:
N TYPE FEMALE

LIGHTNING PROTECTION
GROUNDED DIRECT

LENGTH: 16 FT.
WEIGHT: 5 LBS. 3 OZ.
WIND LOAD: 90 MPH
MOUNTING: UP TO 2 IN. MAST
CAN SIMULCAST ON BOTH BANDS

WATERPROOF CONNECTING JOINTS

UPS SHIPPABLE



AMATEUR SPECIAL

NCG

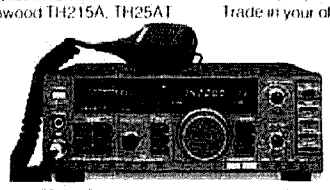
1275 NORTH GROVE ST.
ANAHEIM, CALIF. 92806
(714) 630-4541
CABLE: NATCOLGLZ
FAX (714) 630-7024

✓ 128

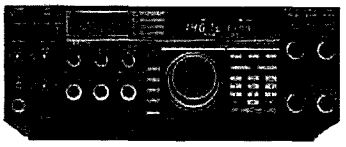
MADISON SHOPPER

CALL FOR ORDERS
1 (800) 231-3057
1-713-520-7300 OR 1-713-520-0550
TEXAS ORDERS CALL COLLECT
FAX 1-713-771-7759
ALL ITEMS ARE GUARANTEED OR SALES PRICE REFUNDED

New Icom IC 781 — Trades wanted
Kenwood TH215A, TH25AT — Trade in your old HT



Kenwood TS 140S — Call for trade
New Kenwood TM 221A 45W mobile — Call
ICOM 28H/T TM — 410.00



Icom 761	2300.00
Shure 444D	54.95
HEIL BM10 Boom Mike	69.00
HEIL HM5 Desk Mike	59.00
Isopole 144 MHz	44.95
Cushcraft 124-WB (146 MHz)	33.00
Butternut HF6V 80-10 vertical	125.00
Hustler G7-144	119.95
KLM KT-34A	399.00
NEW KLM 1 2-44LBX	129.00
G5-RV	44.00
Larsen 2 meter on glass	49.95
New Larsen LM 490 CO	5.00
Anteco 2M, 5/8, Mag. Mount, Comp	25.00
Thousands of panel meters	3.95 up CALL
8560A	95.00
Aerovox 1000 pf/500 V feedthrough caps	1.95
Transformer 120 V Pri., 1050 V/1A (Sec. #18 Wire)	50.00
100 mfd/450V Axial Cap	2.00
831SP-PL259 Silverplate	1.25
82-61 N Male	3.00
GE 6146B	13.95
3-500Z	140.00
GE 12BY7A	7.00
6MJ6	12.95
6KD6	12.95
Cetron 572B	88.00
6JB6A	9.95
8950	18.00
AEA PK-232 with new WX FAX	299.00
Kantronics KPC II	149.00
AEA Packet Terminal	Call
Kantronics KAM/WX	299.00

USED EQUIPMENT
All equipment, used, clean, with 90 day warranty and 30 day trial. Six months full trade against new equipment. Sale price refunded if not satisfied.
Call for latest used gear
(800) 231-3057
TS-430S, TS-830S, TS-520S, FT101E, and Collins

Porcelain 502 Guy Insulators (1/4) — 3.39

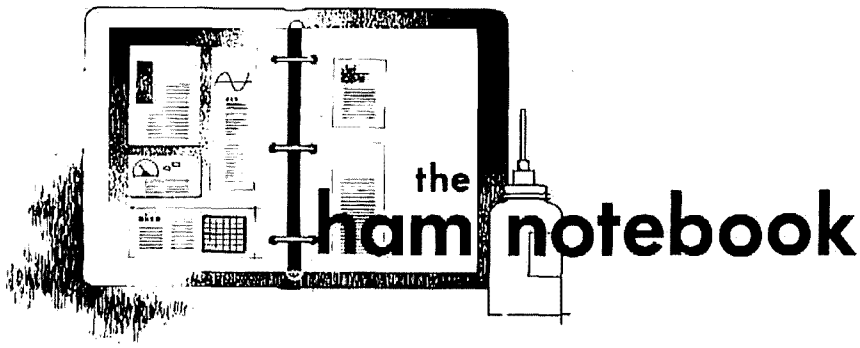
POLICIES
Minimum order $10.00. Mastercard, VISA, or C.O.D. All prices FOB Houston, except as noted. Prices subject to change without notice. Items subject to prior sale. Call anytime to check the status of your order. Texas residents add sales tax. All items full factory warranty plus Madison warranty.

Bird and Belden products in stock. Call today. 129

MADISON
Electronics Supply

3621 FANNIN
HOUSTON, TEXAS 77004

MasterCard VISA



three-band sloper for 7, 18, and 24 MHz

Anticipating the activation of 18 MHz for United States Radio Amateurs and because I needed an antenna for 24 MHz, I built the sloper shown in **fig. 1**. On 24 MHz the 27-foot, 10-inch section is three quarter waves long. The 24-MHz trap isolates the remainder of the antenna on this band. On 18 MHz the entire antenna again resonates as three quarter waves. On 7 MHz the antenna is roughly one quarter wavelength long and provides a low SWR.

The sloper is hung from the top of a 40-foot tower which supports a three-element tribander. My sloper produced SWRs of 1.5 or less across all three bands. Pruning the 4-foot, 10-inch section and adjusting the slope affects performance on 7 and 18 MHz.

The inductance L is ten turns of No. 14 wire on a 1-5/8 inch diameter form. The 2-inch long coil has an inductance of 2.2 μH. The capacitor (see **fig. 2**)

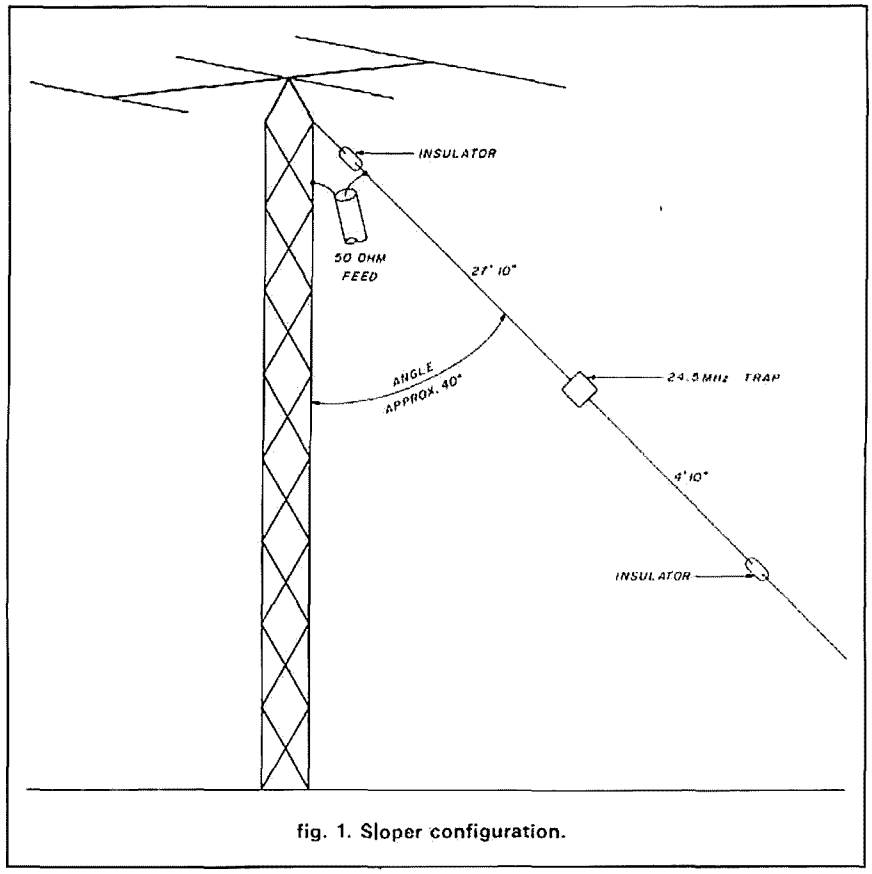


fig. 1. Sloper configuration.

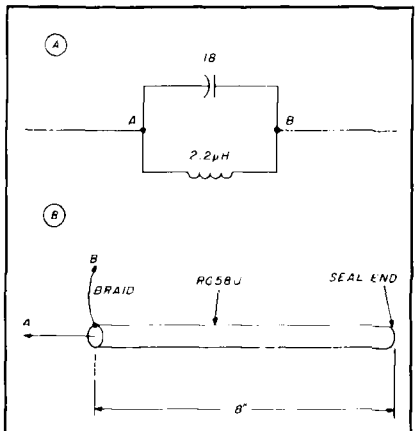


fig. 2. Trap details.

is approximately 8 inches of RG-58. Prune and adjust the trap with a GDO to 24.5 MHz.

Jack Najork, W5FG

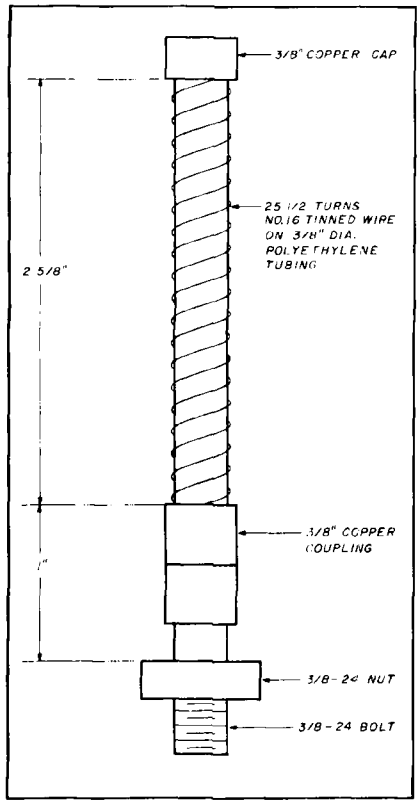
miniature 2-meter mobile antenna

A full-size 2-meter mobile antenna is not needed to work local repeaters, and may be undesirable. I had to remove my 5/8-wave thread-mount antenna every time I garaged my van, so I stopped using the rig on short trips. A highly visible mobile antenna can also be an invitation to thieves and vandals. Considering the options, I realized that since I could work my favorite 2-meter repeaters using a rubber duck on a handheld, a similar antenna would do at least as well on the van.

Figure 1 shows the construction. To make a threaded base for the antenna, I sawed the head off a 3/8-24 bolt and soldered on a stopnut. A coupling for 3/8-inch copper tubing was soldered to the bolt. Three and one-half inches of 3/8-inch diameter polyethylene tubing was inserted into the coupling to support the coil — made by close winding 32 turns (about 38 inches) of No. 16 tinned wire on a 3/8-inch drill bit. I slipped it over the polytubing and stretched it for a tight fit. A copper tubing cap was used to terminate the top of the coil in a small capacity hat.

I tuned the antenna by alternately measuring SWR and tack soldering bits of wire between the coil turns at the top of it to short them out. Shorting 6-1/2 turns minimized the SWR. I removed these turns, cut off the excess poly tubing, and resoldered the end of the coil to the cap. After confirming that the SWR remained low (nearly 1:1 at 145 MHz), I covered the completed antenna with heatshrink tubing.

Ideally, the bolt and nut should be brass for corrosion resistance, easy soldering, and good conductivity. Brass 3/8-24 hardware is difficult to find, but zinc-plated steel will work if



soldered carefully with a good flux. However, it may rust. Do *not* use cadmium-plated hardware — it may produce *highly toxic* cadmium fumes when heated.

Polyethylene has good dielectric properties and low rf loss; some other types of plastic do not. Many hardware stores carry polyethylene tubing (recognized by its stiffness and milky appearance). You can test questionable material for rf loss by placing it in a microwave oven beside of a cup of water (to act as a load); the material should not be hot after one minute of exposure.

Soldering wire to the copper fittings without melting the tubing is tricky. Work quickly: tin the fittings before assembly, and use a high-wattage iron.

My antenna mount extends about 1 inch above its bracket, adding an inch to the electrical length of the antenna. If your mount is different, you may need to experiment with the number of coil turns.

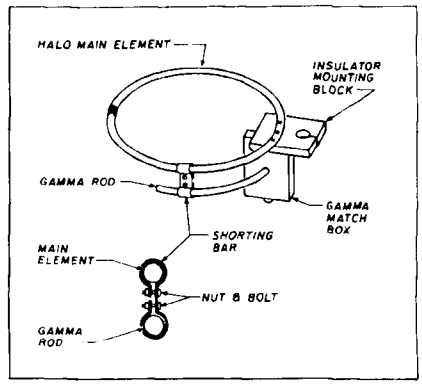
This antenna meets all my needs for local communications. It covers the entire band with less than 2:1 SWR, and with 25 watts I have no trouble working repeaters 20 miles away. Best of all, I can leave it on my van.

Gary Myers, K9CZB

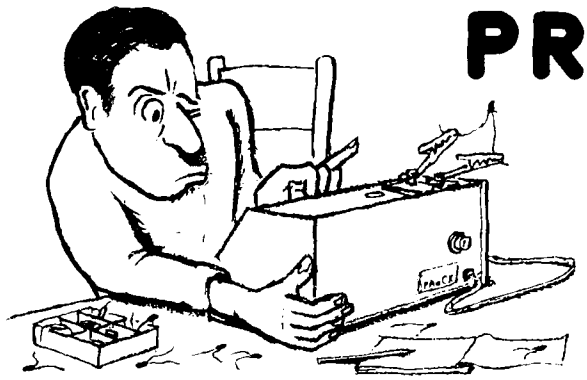
short circuit

2-meter halo antenna

Figure 3 of N6RA's May 1987 article, "A 2-Meter Halo Antenna," should show a wire going from the center pin of the SO-239 to the rotor plate of the gamma match capacitor. Also note that the halo's main element and gamma rod were bent around a large pot to form them in the circular shape. The illustration below shows



the halo and gamma rod in clearer detail than the original **fig. 3.**



PRACTICALLY SPEAKING

Joe Carr, K4IPV

feedback

Feedback is a necessary component of control systems, quality amplifiers, and other circuits. It is also important for magazine writers and publishers. That's why I publish my address each month, encourage people to make comments about what I've said (positive and negative), ask questions, and make suggestions for future columns. In at least one instance I wrote a reply to a reader question, and then edited and expanded it to become a column.

In June 1987 we discussed time domain reflectometry (TDR) – a measurement method in which an oscilloscope and pulse (or square wave) generator are connected in parallel with each other across the input end of a transmission line (**fig. 1**). By analyzing the interference of forward and reflected waves we can deduce much about the transmission line and its load. The article included oscilloscope photos of waveforms associated with various resistive loads.

This month we will discuss some points you readers felt I overlooked in my June 1987 column. For those of you who may have missed it, I will briefly reiterate some of the basics of TDR measurements.

review of TDR

Figure 1 shows the basic setup for TDR testing of transmission lines. You need a moderately wideband scope. Because square waves (or pulses) in the 10-kHz to 3-MHz range are used, the vertical bandwidth should be at least 15 MHz. This enables fast leading and trailing pulse edges to be reproduced with only slight degradation. Adjust the pulse width (or square wave period) to permit the reflected pulse to return to the source while the pulse is still high. Accordingly, adjust the signal generator output to approximate the length of the line. I have found it best to adjust the period/duration to permit the reflection to hit the waveform close to the center of the pulse.

A reader asks, "How does one determine the length of the transmission line from the TDR display?" **Figure 2** shows a pulse as displayed on the oscilloscope when the line is matched to the load. The pulse width is 0.9 μs. Because the connectors on the end of the line represent an impedance discontinuity, there is a small reflected signal which shows up on the display as a "pip" on the top of the pulse. A matched load, with the discontinuity, is easier to measure than a mismatched load, because the point at which the discontinuity occurs is easier to see.

In a test setup I used 100 feet (30.5 meters) of RG-58/CU cable connected to the load box described in my June 1987 article. The square-wave generator was adjusted to produce a waveform with a period of 1.8 μs, so the high portion was one-half that amount, or 0.9 μs. The cable I used had a polyethylene (not foam) dielectric, and according to standard wisdom, has a velocity factor of 0.66. Test results found the "pip" at 0.3 μs, which means that a round trip took 0.3 μs. Calculate the length of the cable using the formula below:

$$LENGTH = \frac{c\ V\ T_d}{2} \qquad (1)$$

Where:

LENGTH is the length in meters

c is the speed of light (3 x 10^8 m/s)

V is the velocity factor

T_d is the round-trip time measured on the oscilloscope

Using our example:

$$LENGTH = \frac{c\ V\ T_d}{2} \qquad (2)$$

$$LENGTH = 29.7, \text{ or} \qquad (3)$$

$$\frac{(3 \times 10^8\ m/s)\ (0.66)\ (3 \times 10^{-7}\ sec)}{2}$$

Within experimental accuracy (measurement of both the length of the coax and the return time) this result agrees closely with the actual physical situation. We can also measure the velocity factor of a particular sample of transmission line using the TDR approach. Rearrange the same equation to solve for V:

$$V = \frac{2 \times LENGTH}{c\ T_d} \qquad (4)$$

Which is calculated at 0.66.

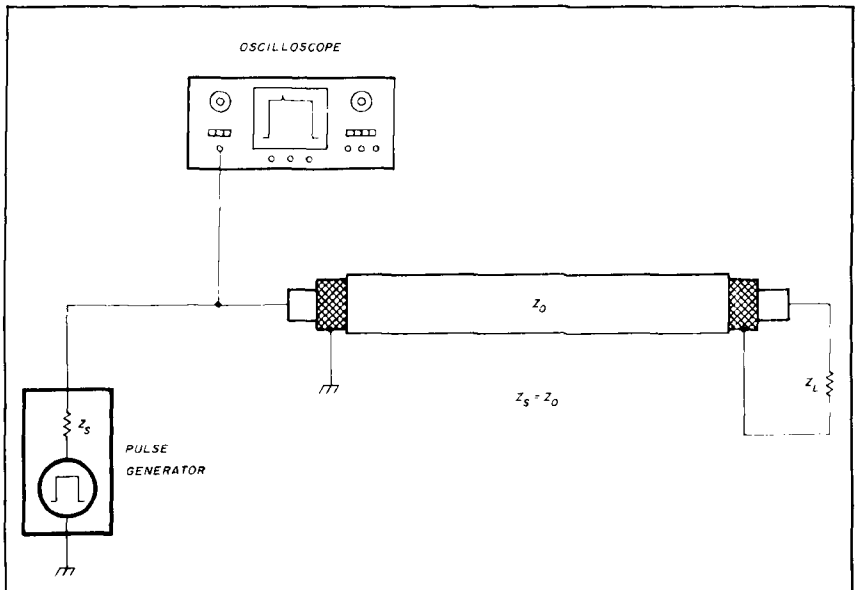


fig. 1. Time Domain Reflectometry (TDR) test set-up.

another sawtooth generator

In several columns we discussed the Poor Man's Spectrum Analyzer project. I offered a digitally derived sawtooth generator circuit to replace the original one. In response to the column I received a circuit from Isak Nowik (SMØNHS) in Stockholm. The simple circuit in **fig. 3** is based on the 555 timer IC. The basic circuit is the monostable multivibrator configuration of the 555, in which one of the timing resistors is replaced with a transistor operated as a current source (Q_1). You can use almost any audio small signal NP silicon replacement transistor, although for this test I substituted a Radio Shack replacement for the 2N3906 device (sold in packs of 15). The zener diode specified by SMØNHS was 4.3 Vdc, but I used a 5.6 Vdc unit that happened to be on hand and it worked well. Note that the output is taken from pins 6-7, rather than the regular chip output, pin no. 3.

Looking at **fig. 4**, you can see that the sawtooth wave is a lot more linear than the original sawtooth available from the spectrum analyzer sweep board. The period of the sawtooth is set by capacitor C_3 in **fig. 3**. SMØNHS recommended 100 to 500 pf, which is

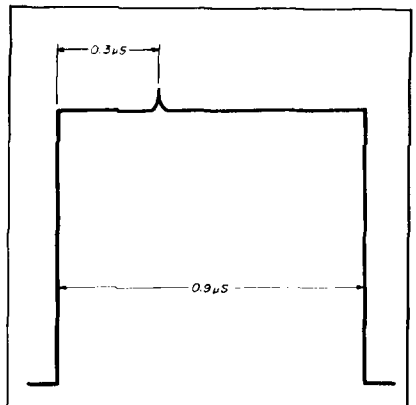


fig. 2. Oscilloscope display for TDR test. "Pip" is caused by the interference of forward and reflected signals.

fine for some purposes, but for the slow speeds needed in the spectrum analyzer I found that increasing the value to 0.01 provided a better tradeoff. The value is not critical for circuit operation, so experiment with it to meet your particular timing requirements.

The circuit as shown is a one-shot multivibrator. Triggering occurs in the 555 when pin no. 2 is within 66 percent of the supply voltage. When a pulse is applied to pin 2 through differentiating network R_1 C_1, the device will trigger because the negative-going slope meets the triggering criteria. To make an astable sawtooth multivibrator, drive the input of this circuit with either a square wave or pulse train that produces at least one pulse for each required sawtooth. Because the circuit of **fig. 3** is a nonretriggerable monostable multivibrator it will ignore subsequent trigger pulses during the one-shot's "refractory" period.

transmission line stubs

Transmission line sections can be used for impedance matching in antenna systems and other applications. In microwave circuits, transmission line segments are commonly used to match system impedances (e.g., 50 ohms) to device impedances. A quarter-wavelength transmission line has an interesting property. The impedance "looking-into" the line is equal to:

$$Z = \frac{[Z_0]^2}{Z_L} \qquad (5)$$

Where:

Z is the driving point (or input) impedance

Z_0 is the characteristic impedance of the line

Z_L is the load impedance

By forcing the characteristic impedance to a specific value we can force the input impedance to match the source impedance. For example, when we have a source impedance Z_S (such as the output impedance of a transmitter), we can rearrange the equation above to find the characteristic impedance the quarter-wave transmission line requires to effect the match:

$$Z_0 = [Z_2\, Z_L]^{1/2} \qquad (6)$$

In many applications the usefulness of this fact is limited by the available standard transmission line impedances. But in UHF and microwave work we can design pc transmission lines that have any practical impedance. We can also design custom parallel transmission lines for hf and VHF antennas.

Another application of the line, a shorted quarter-wavelength transmis-

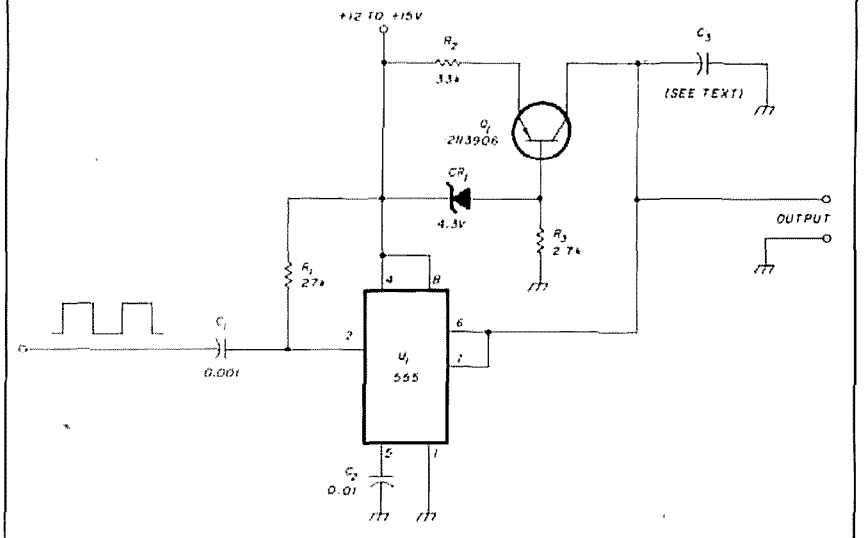


fig. 3. Linear sawtooth generator based on 555 IC timer.

sion line, offers an infinite impedance across the input terminals, but also a phase reversal of the signal. Because of this, shorted quarter-wavelength stubs are sometimes used in VHF antenna projects. One point some Amateurs miss, is that shorted stubs of other lengths can be used to produce almost any practical value of reactance. The impedance of a random length of transmission line is found from:

$Z = jZ_0TAN(2\pi fZ_0CL)$

Where:

Z is the impedance looking into the shorted line

Z_0 is the characteristic impedance of the line

f is the frequency in hertz

C is the capacitance per unit length in farads

L is the length in meters

This equation's usefulness is apparent when matching antennas that are reactive. Most Amateur Radio literature tells us to add some capacitance to match an inductive antenna, and vice versa. This is merely a restatement of the fact that the match of a complex impedance (to make it resistive) is the complex conjugate of the impedance. For example, if we have an impedance of 50 − j30 ohms, we can

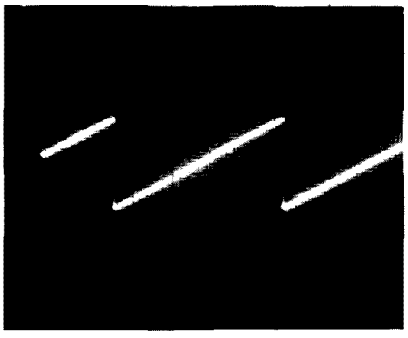


fig. 4. Sawtooth output from circuit of fig. 3.

match it with a network that looks like 50 + j30 ohms. The reactive components cancel each other, leaving the impedance resistive.

The equation above contains a "j-operator" telling us that the answer is reactive; a "−j" says it is capacitive reactance, while a "+j" says it is inductive. Thus, a shorted matching stub, with a length designed to cancel out the reactance, can be placed at an antenna feedpoint in lieu of an inductor-capacitor matching network.

Joe Carr, K4IPV, can be contacted at POB 1099, Falls Church, Virginia 22041. Reader comments, inquiries, and recommendations are welcomed.

ham radio

★ COMPUTER ★
SUPPLIES

Disk File 5 up to 75 5¼ disks	6.95
Media Mate 5 w/lock 5¼	11.95
Library Case up to 10 5¼	2.25
Versa Pak up to 6 5¼	1.95
Micro-Disk 10 up to 10 3½	3.25
★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	
6-Outlet Surge Suppressor	9.99
Curtis Printer Stand	19.99
Computer Tool Kit	22.99
XT System Stand	22.99
Curtis A-B Data Switch	39.99

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★
WORLD DATA ENTERPRISES
1-800-634-3547
(305) 551-4023
P.O BOX 652737 MIAMI, FL 33265
*PLUS SHIPPING/HANDLING

143

★DISKETTES★

Bulk 5¼ DSDD w/o Sleeves	.39
Bulk 5¼ DSDD w/Sleeves	.45
Maxell DSDD 5¼	7.99
Maxell DSHD 5¼	22.99
Nashua DSDD 5¼	9.99
Nashua DSHD 5¼	16.99
3M DSDD 5¼	12.99
3M DSHD 5¼	22.99
Maxell 3½ DSDD	24.99
3M 3½ DSDD	22.99

WORLD DATA ENTERPRISES
1-800-634-3547
(305) 551-4023
P.O BOX 652737 MIAMI, FL 33265
*PLUS SHIPPING/HANDLING

CADDELL COIL CORP.
35 Main Street
Poultney, VT 05764
802-287-4055

BALUNS
Get POWER to your antenna! Our Baluns are already wound and ready for installation in your transmatch or you may enclose them in a weatherproof box and connect them directly at the antenna. They are designed for 3-30 MHz operation. (See ARRL Handbook pages 19-9 or 6-20 for construction details.)

100 Watt (4:1, 6:1, 9:1, or 1:1 impedance—select one)	$10.50
Universal Transmatch 1 KW (4:1 impedance)	14.50
Universal Transmatch 2 KW (4:1 impedance)	17.00
Universal Transmatch 1 KW (6:1, 9:1, or 1:1—select one)	16.00
Universal Transmatch 2 KW (6:1, 9:1, or 1:1—select one)	18.50

Please send large SASE for info.

Yagi vs. Quad: part 1

Development of the quad model

Few controversies in Amateur radio have sparked as much interest as the debate over which is the better antenna: a Yagi or a quad. Comparing models of both antennas at 440 MHz suggested that for a given boom length, the quad antenna holds about a 2-dB advantage.[1] However, this advantage does not seem to hold for quads on lower frequencies.[2]

This article approaches the Yagi vs. quad controversy from a different perspective, that of computer models. While a computer-generated antenna design is a step or two away from the real thing, it allows for greater manipulation of antenna geometry and a reproducible means of measuring antenna gain which is difficult to achieve in a real-life situation. Both Yagi and quad antennas may be "tuned" to maximize a specific parameter — for instance, maximum forward gain. Thus a Yagi and a quad may be compared for a given boom length and tuned for maximum forward gain, without worrying about compromising gain performance due to tuning for front/back discrimination or bandwidth.

An efficient means of analyzing quad antennas has not, to my knowledge, been developed. Although quads may be analyzed using general analysis programs such as NEC and MININEC (see Appendix for brief description of these programs) they require enormous amounts of computer time. A NEC modeling of a four-element quad with 40 match points per element requires computing and inverting a 1600-element complex matrix, not an easy job for a Macintosh. By accepting some simplifying assumptions we can develop a means of analysis similar to that successfully used for Yagi antennas.[3],[4] The three needed parameters are: an estimate of element self-impedance (both real and imaginary), the mutual impedance between elements, and the field pattern of the quad loop.

In Part 1 of this article we will develop a means of estimating these parameters and examining the two-element quad. In Part 2, various quad configurations will be altered to maximize forward gain for a given boom length, and the calculated maximized forward gain will be compared to that found for similarly manipulated Yagi antennas. The following three sections deal with the estimation of the quad model. Skip to the "two-element quad" paragraph if you wish to avoid technical aspects not essential for an understanding of this series.

estimation of self-impedance

I originally tried to use MININEC, a general analysis

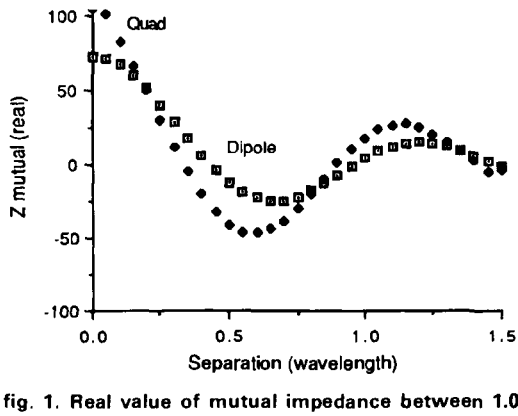


fig. 1. Real value of mutual impedance between 1.05 wavelength quad loops and 0.5 wavelength dipole elements as a function of separation. Note the similarity in the trajectories and the large magnitude of the quad values. This suggests that quad loops are at least as well coupled as Yagi elements.

By Dave Donnelly, K2SS, 8 Alder Street, Lincoln Park, New Jersey 07035

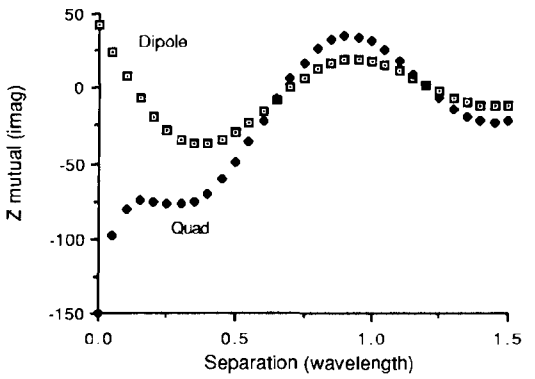


fig. 2. Reactive values of mutual impedance between 1.05 wavelength quad loops and 0.5 wavelength dipole elements as a function of separation.

program, to estimate the self-impedance of a quad loop. I started breaking a single 1-wavelength quad loop into 16, 40, 80, and 160 segments and examined the computed pattern and driving point impedance. While the loop gain and pattern were constant as the number of segments increased, the estimate of self-impedance did not converge on a single value. This poor convergence was worse as the quad element wire got thinner. Compounding this, the computer results showed that a 1-wavelength loop was shorter than resonant. In contrast Lawson had predicted, using different assumptions, that the zero reactance point on a quad loop should be close to one physical wavelength.[5] Why the discrepancy?

Rather than rely on computed values, I decided to measure the impedance. I bought four Fiberglas™ spreaders, strung out a 1-wavelength loop of No. 14 stranded wire at 14.1 MHz, and moved the loop up and down an 80-foot tower while measuring the drive impedance with a Delta Electronics OIB-2 impedance bridge. I measured the drive impedance between 14.0 and 14.3 MHz, and at several different heights. Assuming that the presence of the tower and coupling of the bridge to the element (or element to ground) did not affect the measured value, I estimated the drive impedance from measured values as: R = 381•L − 277 (R = real component) and X (reactive or imaginary component) = 2330•L 2452, where L is the element length in wavelengths. A 1 wavelength loop measured 104 − j152 ohms, which is close to that calculated by MININEC using 80 match points (108 − j162).

mutual impedance

The calculated values for impedance using MININEC were found to be stable for larger wire diameters (1-inch diameter wire at 14 MHz). Mutual impedance was calculated by constructing two identical 1.04-wavelength loops (1-inch diameter wire), separated by 0.05 wavelength and calculating mutual impedance from the induced current in the second loop due to current in the first loop:

$$Z_{12} = \frac{V_1 - I_1 Z_{11}}{I_2} \quad (1)$$

where V_1 is the voltage applied to the first loop, I_1 is the current in the first loop, I_2 is the current induced in the second loop and Z_{11} is the self-impedance of the first loop. The real and imaginary parts are plotted in **figs. 1** and **2**, with similar values computed for half-wavelength dipoles shown as a comparison. As you can see, the magnitude of mutual impedance (or coupling) between quad elements stays quite large as the elements are separated. This suggests that the old adage that quad elements are a "Low q" circuit and hence are poorly coupled is *wrong!*

pattern

The quad field pattern computed by MININEC was stable as the number of segments increased and could be trusted for an accurate field description. The field pattern was translated into spherical coordinates and used for subsequent pattern and gain computation. A 1-wavelength loop showed 3.01 dBi gain compared with 2.18 dBi for a dipole. This gain for a square quad is consistent with that calculated using different methods.[5] These estimates of self- and mutual impedances for quad loops allowed the computation of the mutual impedance matrix. The currents flowing at the center of each element are determined by inversion of this matrix and multiplication by the driving voltage at each element. The pattern and gain can now be calculated from these currents.[6] As in reference 6, it is assumed that the mutual impedance and single element pattern are independent of element

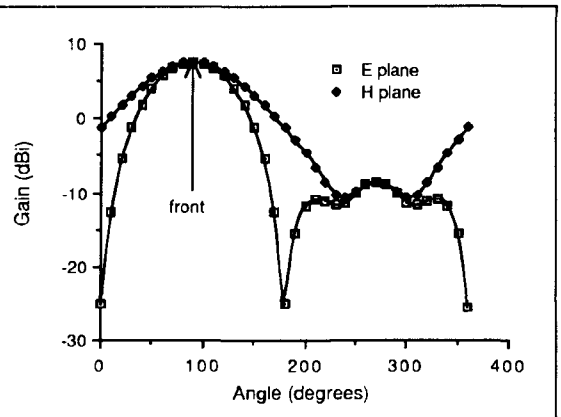
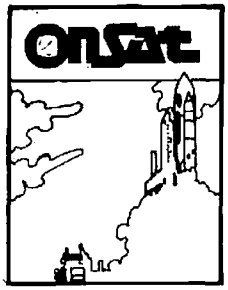


fig. 3. Free space pattern of 2-element quad with reflector = 1.050 wavelength, driven element = 1.021 wavelength and spacing = 0.15 wavelength. Note good front/back of about 20 dB.

OnSat

"America's Weekly Guide to Satellite TV"



The best in satellite programming! Featuring: ★ Over 120 Channels listed ★ Weekly, Updated Listings ★ Magazine Format ★ Complete Alphabetical Movie Listings ★ Sports Specials ★ Prime Time Grids ★ Specials ★ Programming Updates!

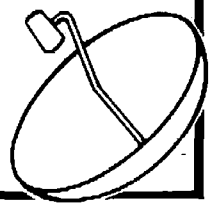
- **Only $45.00 per year (52 weekly issues)**
- **2 Years $79.00 (104 weekly issues)**
- **$1.00 for sample copy**

*NC Residents must add 5% Sales Tax

Subscribe Today!

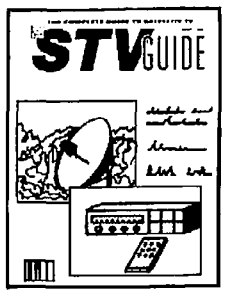
call toll free 1-800-234-0021
Visa® and MasterCard® accepted

OnSat PO Box 2347 Shelby, NC 28151-2347



STV GUIDE

The new **STV Guide** contains valuable information on zoning regulations, scrambling, plus technical tips for installing or updating a satellite system—and now a precise monthly guide to satellite TV with the latest program listings for over **90 channels**!



All this in each complete issue of **STV Guide**!

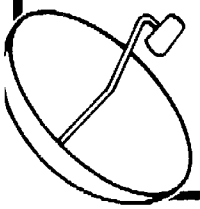
- **Only $48.00 per year (12 monthly issues)**
- **$2.00 for a sample copy**

*NC Residents must add 5% sales tax

Subscribe Today!

Call toll free 1-800-234-0021
Visa® and MasterCard® accepted

STV Guide PO Box 2384 Shelby, NC 28151-2384



148

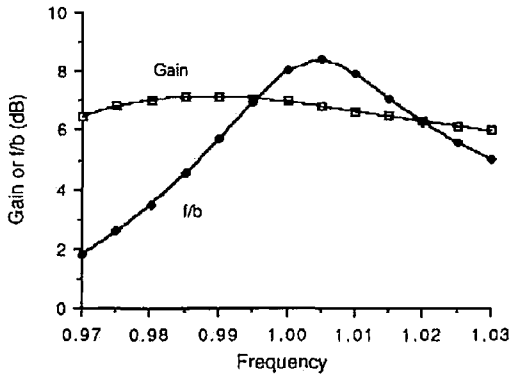


fig. 4. Free space forward gain and front/back as a function of frequency for a 2-element quad with reflector = 1.050 wavelength, driven element = 1.021 wavelength and spacing = 0.15 wavelength. Front/back values are divided by 2 hence vertical scale for front/back should be 0-20 dB. The 2-element quad retains good gain over a 4 percent change in frequency.

length. Although this is not exactly true, it is hoped that the "not true" part is minor. Since this assumption works for Yagi antennas it should also work for quads.

two-element quad

The dimensions for a two-element quad were taken from the *ARRL 1986 Handbook*: REF = 1006/Freq and Driven element = 999/Freq. Once again, I was skeptical of the computer model since my calculation of self-impedance indicated that this ARRL reflector was shorter than resonant. (I always believed that reflector elements should be longer than resonant.) However, computer results indicated that this antenna worked well. Forward gain with a spacing of 0.15 wavelength was 7.5 dBi and front/back was 17 dB, straight off the back (**fig. 3**). Bandwidth was sufficient to cover both the phone and CW segment if constructed for any band between 10 and 40 meters (**fig. 4**). The forward gain as a function of element separation indicated a maximum forward gain occurring at 0.15 wavelength (**fig. 5**). Increasing the reflector length to 1.040 wavelength while keeping the spacing constant at 0.15 wavelength could increase forward gain to 8.0 dB, but also caused a low of front/back to 10.6 dB.

conclusions

The results suggest several conclusions: (1) The gain of a single quad loop is 3.0 dBi compared with 2.16 dB for a dipole. (2) Coupling between quad elements is at least as good as Yagi elements, but the reactive value is quite different from dipole elements — staying negative until elements are separated by 0.7 wavelength. (3) Despite having a reflector which is actually shorter than resonant, a two-element quad from the

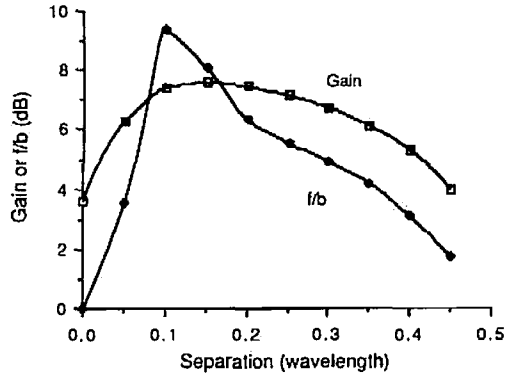


fig. 5. Free space forward gain as a function of element separation for a 2-element quad. Reflector = 1.050 wavelength and driven element = 1.021 wavelength. Front/back values are divided by two.

Antenna Handbook has good pattern and gain comparable to a two-or-three element monoband Yagi on the same length boom, but the gain is less than that for an optimum spaced three-element Yagi.[6]

In the next part we will calculate the performance of larger quads, examine the improvement that may be expected when gain is optimized, and compare calculated forward gains with similarly computed gains from Yagi antennas.

appendix

The single quad loop field pattern and two-loop mutual impedance values were estimated using MININEC, a general analysis program for thin wire antennas written by Alfredo Julian and colleagues at the Naval Ocean System Center. This program uses the method of moments for obtaining the current distribution along any antenna. Basically, the antenna is broken into many small pieces, the current is assumed constant along any given piece, and the wave equations are simultaneously solved to give a current distribution. The accuracy of the solution depends on breaking the antenna up into enough small pieces so that the calculated current distribution is smooth and approximates the real thing.

The MININEC program used here was slightly modified: it was translated from the original BASIC language into PASCAL and the matrices were expanded to allow for more match points.

references

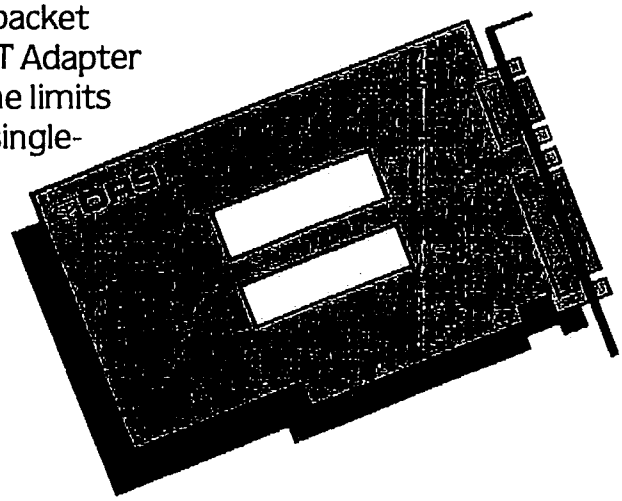
1. J.E. Lindsay, "Quads and Yagis," *QST*, May 1968, pages 11-19.
2. W. Overbeck, "Quads and Yagis Revisited," *ham radio*, May 1979, pages 12-21.
3. J.L. Lawson, "Yagi Antenna Design: Performance Calculations," *ham radio*, January 1980, pages 22-27.
4. J.L. Lawson, "Yagi Antenna Design: Experiments Confirm Computer Analysis," *ham radio*, February 1980, pages 19-27.
5. J.L. Lawson, "Yagi Antenna Design: Quads and Quagis," *ham radio*, September 1980, pages 37-45.
6. D.F. Donnelly, "Optimizing Gain on Yagi Antennas," *ham radio*, March 1988, pages 21-24.

ham radio

Packet Radio WITHOUT a Packet TNC!!

▲ ▲ ▲ ▲ ▲

All aboard for the next generation of packet software capabilities. DRSI's PC*PACKET Adapter is the first step to advancing beyond the limits imposed by small address spaces and single-purpose hardware. Together with the HF*MODEM, get two TNC's on one short card that works in IBM PC/XT/AT's or clones. The PC*PACKET Adapter and software is $119.95. The HF*Modem with tuning indicator is $59.95. Call now!



▲ ▲ ▲

Goes
On Sale At
Dayton Hamvention

DRSI
Digital Radio Systems, Inc.
2065 Range Rd. ▲ Clearwater, FL 34625 ▲ (813) 461-0204

a shortened 40-meter four-element sloping dipole array

Instant azimuth change by switching characteristics of each element

Here's how to build a four-element sloper system for 40 meters on a small city lot using the same mast that supports your triband Yagi.

One of the best low-angle radiators for the lower bands is a vertical *dipole*. It concentrates the radiation at low angles and lessens dependence on a radial system, often a problem in vertical arrays. The radials are not as necessary as are verticals that have their maximum current at ground level.

Though the dipole in this array may not be exactly vertical, the signal is vertically polarized with a low angle of radiation. To get both directivity and gain, space several elements around a single support and use a switching network to select one dipole as the driven element. At the same time, lengthen the other dipoles electrically to act as reflectors. Add a 3/8-wavelength stub to make the dipole, which is self-resonant at the operating frequency, perform like a reflector. This stub looks inductive to the antenna and decreases its resonant frequency by about 5 percent. Select one of the sloping dipoles through the switching network to electrically rotate the antenna pattern.

We live on a small city lot, and our tower with a five-element tribander at the top is a rather fragile one guyed to resist strong winds. At first it seemed impossible to use any slopers because of potential interaction with the guy wires. The problem was solved by replacing the metallic wires with strong nylon rope. Good UV-resistant nylon ropes are available in yachting shops. (Do *not* use ropes designed for mountain climbing!) Four dipoles, spaced 90 degrees apart, are run along the nylon rope. Usually a tower has only three guys, separated by 120 degrees. Three elements are probably just as effective, as observations of the incoming signals show that the forward lobe is rather broad.*

shortened elements

The tower is about 56 feet high, and two of the four guys are fastened to the house about 6 feet above ground — a serious problem. Consequently, with the maximum possible element length, shortened dipoles had to be used. My design, shown in **fig. 1**, uses a 4.5 μH inductance in each leg. A coil, 12.5 turns, 1.5 inches in diameter and 1.4 inches long, provides the value of inductance.

Tuning of each shortened dipole is critical. They were tuned in a horizontal position about 13 feet above ground. As each antenna was put on the tower, the resonant frequency changed. I spent quite some time tuning the elements for resonance by connecting one element through an SWR bridge to the transmitter while the other elements were disconnected. Though not grounded, they must be there with the required open feedline as there is always some interaction between the elements. Each element has to be tuned for the same resonant frequency and must show the same SWR across the band in order to switch direction without retuning the transmitter or linear. **Figure 2** shows a plot of SWR for one of the elements. The resonance is in the CW portion of the band. To tune for a higher frequency, just shorten the antenna.

*Using a similar array for 80 meter, Fuller, W2LU, comes to the same conclusion. See reference 2.

By Jurgen A. Weigl, OE5CWL, Karntnerstr. 212/59, A-8053 Graz, Austria

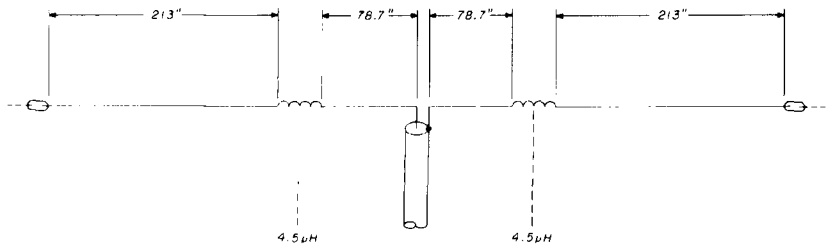


fig. 1. Shortened 40m element lengths and loading coil locations.

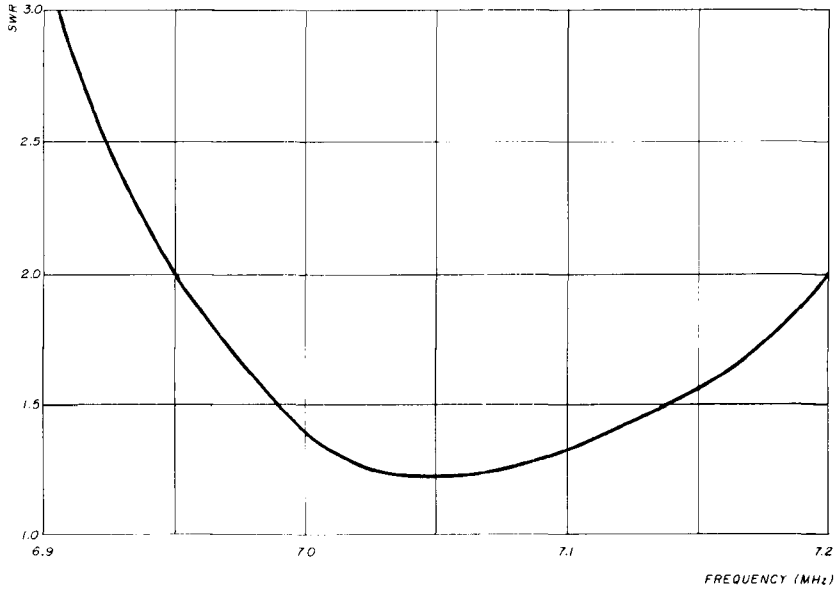


fig. 2. Shortened 40m dipole SWR versus frequency. Antenna was tuned for lowest SWR over the European segment of the band. Note the SWR is less than 2.0:1 over 200 kHz of bandwidth.

attaching the dipoles to guy lines

The antenna should be attached to the guy at only three points. The guy line passes through the tube of the upper loading coil, through a small loop fastened to the center insulator, and then through the tube of the lower loading coil. The upper end of the antenna is suspended from a 20-inch rope. Be sure the antenna moves along the guy freely or it may break in strong winds.

controlling the direction

Figure 3 shows the basic antenna layout. The feedlines (3/8 wavelength long), which connect the various elements to the control box, are a vital part of the system. Remember that you have to consider the velocity factor of your coax cable. **Equation 1** gives you the physical length for cutting your feedlines.

$$\ell = 0.375\ \lambda K \qquad (1)$$

where λ = wavelength

K = velocity factor

For RG-8 or RG-58 coax, K is about 0.66 so λ is 36 feet. You can determine the velocity factor for other cables from antenna handbooks. Do not use inexpensive TV coax since no reliable velocity factor value is available. The feedline from the control box to the transmitter may be any length but should be the same type of cable as the stubs. **Figure 4** is a schematic of the control box. For the four-element array, three relays are required to select the proper feedline. (If you use only three elements, you need only two relays.) The contacts should be rated for about 6 to 10 amps

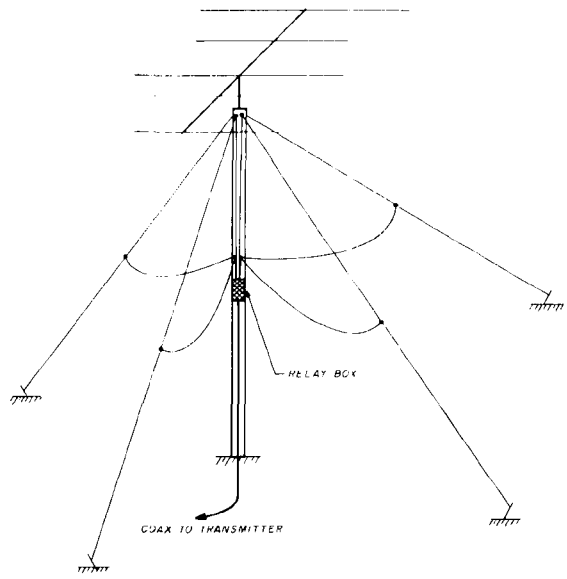


fig. 3. Four element sloping dipole array with tribander atop the tower. Each coaxial line from element to relay box is 36 feet long!

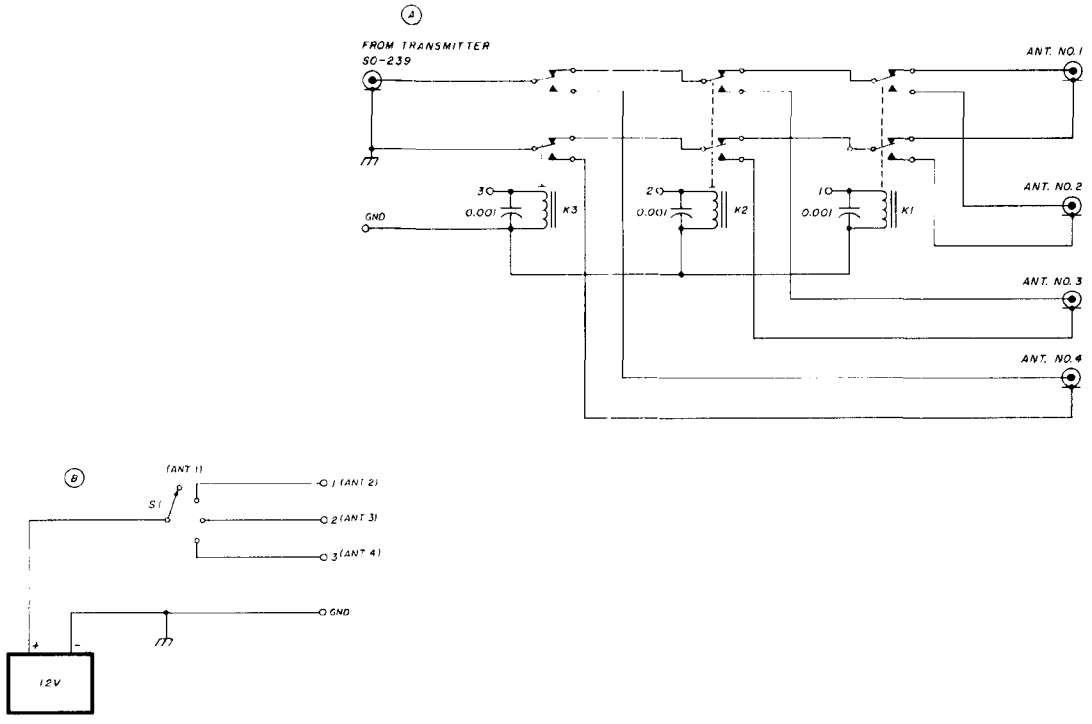


fig. 4. Switching network for the four element sloper array. (A) Tower mounted relay box circuit (a modification of a diagram that appeared in the ARRL 1974 Antenna Handbook) (B) Control unit in ham shack.

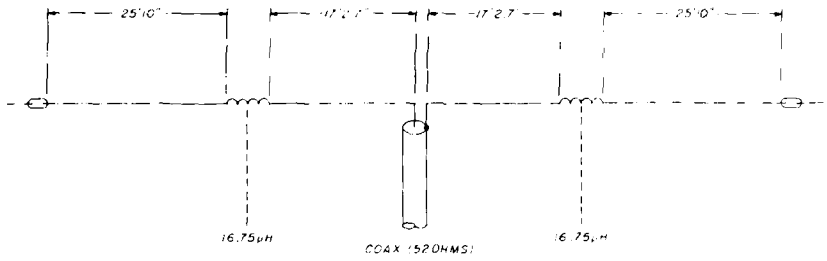


fig. 5. Shortened 80m dipole, overall length 26.1 meters, approximately 86 feet.

and contact spacing should be good for at least 200 volts. This handles up to 800 watts at low SWR. *Never* switch the direction when power is applied to one of the elements — hot switching may result in damage. Because the feedlines of the unused elements are not grounded, the braid of the coax is open circuited when not in use. This is the only way to achieve the proper tuning that allows the elements to act as reflectors.

other bands

I hope this article will encourage you to build this or a similar array. If space permits, use full-size elements. If a shortened dipole is needed, design data is available for other frequencies.[1] An 80-meter dipole for use at 3.8 MHz is described in **fig. 5**. With an antenna tower only 78 feet high you will be able to join other Amateurs with a directive 80-meter antenna. This bandwidth is small but if you use low-loss coils the antenna should be quite effective and possibly achieve 4 dB of gain.

references

1. *The ARRL Antenna Book*, Newington, Connecticut 06111, 1974.
2. Fuller, Eugene B., W2LU, "Sloping 80 meter Array," *ham radio*, May 1979, page 70.

ham radio

MULTIFAX 3.0
(EGA VERSION)

THE EGA VERSION OF MULTIFAX IS NOW AVAILABLE FOR RECORDING AND DISPLAY OF:
* **WEFAX FROM GOES SATELLITES**
* **HF FAX FROM NAVY WEATHER BROADCASTS**
* **APT FROM NOAA POLAR ORBITING SATELLITES**
* **AND OTHER SIMILAR FAX TRANSMISSIONS IN UP TO 16 COLORS ON YOUR IBM OR COMPATIBLE PC.**

MULTIFAX 3.0 (MF3) displays the full picture on the EGA monitor (640 x 350 pixels) during recording. Meanwhile memory is filled with an even finer-grain data so that ANY SELECTED AREA on the picture may be magnified for more detailed viewing.

TIMING is keyboard adjustable, so MF3 is adaptable to all known fax speeds and PC clock rates.

TWO, four, eight, and 16-color recording is selectable in exchange for recording length. Ex: 640k holds one 16-color picture or four 2-color charts. Colors are selectable from any of 64.

DATA entry is via the game port.
All pictures may be printed and/or saved on disk.

PRICE is $49 (US) for MF3 on 5¼ inch disk with instructions and interface circuit information. For previous buyers of MF2 and/or MF2.1, MF3 is $20 (US). Add $4 (US) for delivery outside USA, Canada, and Mexico.

If you are limited to CGA (320 x 200 pixels), MF2.1 is also available at $49 (US.) Send for free detailed descriptive material on either MF2.1 or MF3.0, or both.

Elmer W. Schwittek, K2LAF
2347 Coach House Lane, Naples, FL 33942
813-434-2268

IBM is a registered trademark of IBM Corp.
Multifax is a registered trademark of E. W. Schwittek

W6SAI BOOKS
published by Bill Orr, W6SAI and Stu Cowan, W2LX

BEAM ANTENNA HANDBOOK
Completely revised and updated with the latest computer generated information on BEAM Antenna design. Covers HF and VHF Yagis and 10, 18 and 24 MHz WARC bands. Everything you need to know. 204 illustrations. 268 pages. ©1985. Revised 1st edition.
RP-8A **Softbound $11.95**

SIMPLE LOW-COST WIRE ANTENNAS
Primer on how-to-build simple low cost wire antennas. Includes invisible designs for apartment dwellers. Full of diagrams and schematics. 192 pages. ©1972 2nd edition.
RP-WA **Softbound $11.95**

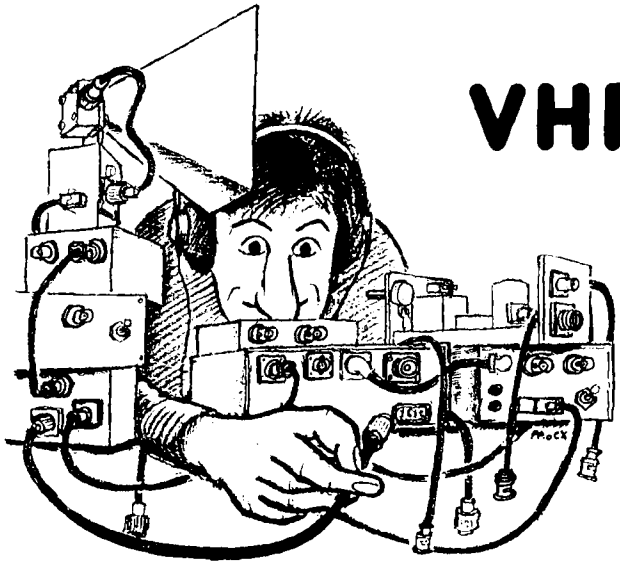
ALL ABOUT CUBICAL QUAD ANTENNAS
Simple to build, lightweight, and high performance make the Quad at DX'ers delight. Everything from the single element to a multi-element monster. A wealth of information on construction, feeding, tuning and installing the quad antenna. 112 pages. ©1982. 3rd edition.
RP-CQ **Softbound $9.95**

THE RADIO AMATEUR ANTENNA HANDBOOK
A wealth of projects that covers verticals, long wires, beams as well as plenty of other interesting designs. It includes an honest judgement of gain figures, how to site your antenna for the best performance, a look at the Yagi-Quad controversy, baluns, slopers, and delta loops. Practical antenna projects that work! 190 pages. ©1978. 1st edition.
RP-AH **Softbound $11.95**

Please enclose $3.50 for shipping and handling. VISA

ham radio magazine BOOKSTORE
GREENVILLE, NH 03048 (603) 878-1441

152



VHF/UHF WORLD

Joe Reisert, W1JR

power splitters and summers

VHF/UHF World has discussed optimum antennas[1,2] high gain antennas[3], and how to obtain additional gain using multiple or "stacked" antennas in an "array".[4,5] At VHF and the lower UHF bands I have often recommended using the longest possible Yagi with a clean pattern.[4] If the antennas do not have the desired gain, an alternative is to stack similar antennas.[4,5]

Stacking usually requires phasing lines and power splitter(s) or summer(s) — Amateurs call them power dividers. Several have appeared in this column, but I still get letters asking how they work, how to design them, and what types I recommend.[5,6]

This month I will discuss various types of power dividers, their advantages and disadvantages and specific electrical and mechanical examples. After reading this column you should be able to either duplicate the designs or build your own.

why use a power divider?

As **references 4** and **5** point out, the first step in antenna selection is to choose the desired gain. Second, select an antenna design that fits your physical requirements. Remember that if the type you choose is a collinear or Yagi, even the largest one may not have the necessary gain. A practical alternative is to "array" or "stack" several of them to reach the gain you want.

Stacking standard or extended/expanded collinears was common practice until the late 1970s.[7] Most collinears use open wire or twin lead transmission lines that are often paralleled to form the power divider function. At the final feedpoint, an impedance matching network or tuning "stub" (and possibly a balun) are used to match the transmission line to the antenna.

With the Yagi, it's common practice to stack antennas one above the other, side by side, or in combinations of both (see **references 4** and **5**). Open wire lines are recommended for stacking, especially on EME, but for reliable all-weather performance they should be configured as described in **reference 5** to maintain a low VSWR.

Nowadays when you want high gain, it is common practice to stack several of the newer high performance Yagis in an array. Since most Yagis have a feedpoint impedance of 50 ohms unbalanced, the use of coaxial power dividers is a natural. Just build up a set of identical phasing lines, connect them to a suitable coaxial power divider, and you're ready to go.

power divider fundamentals

From this point on I will describe only coaxial power dividers — by far the most common types. For more on open-wire line read **references 5** and **7**.

The six most important power divider properties are: impedance, number

Table 1. Some of the common properties of coaxial power dividers as described in the text.

parameter	most common	other common possibilities
Input/output impedance	50 ohms	12.5 to 100 ohms
Number of outputs	2 and 4	6 and 8
Power level at output	-3 and-6 dB	-8 and -9 dB
Phase between outputs	0 degrees	90 and 180
Isolation between outputs	none	>20 dBs typical
Insertion loss	negligible	0.1-0.5 dB typical

of output ports, power level at each output port, phase of each output port, isolation between outputs (if applicable), and insertion loss as shown on **table 1**. Did I miss anything?

Power dividers can be designed for virtually any impedance. If only coaxial phasing lines are used, impedance matching is greatly simplified by using 50 ohm input and output impedances. This greatly reduces the complexity of the phasing lines and the overall array.

Power dividers can theoretically be designed with any number of outputs. The most common types used by Amateurs are symmetrical 2 and 4 way although 6- and 8-way types are sometimes used. The greater the number of outputs, the more difficult it is to impedance match between the input and the output ports and the greater the mechanical complexity. In addition, 8-way power dividers require longer phasing lines which have loss and tend to be counter productive.

In a lossless equal output power divider, the output at each port is a function of the division ratio. For instance, in a two-way divider, the output power will be one-half the input level or minus 3 dB. In a four-way divider the output will be one-fourth the input or minus 6 dB, and so on.

The phase of a power divider's outputs is a function of the design. Amateurs usually prefer the outputs for stacking antennas to all be the same phase, simplifying the phasing line design.

Ninety degree or quadrature phasing may be preferable when antennas are used in circularly polarized arrays. The most common 90 degree power dividers are the two-way quarter wavelength types using hybrid couplers described in last month's column.[8]

The coaxial power dividers favored by Amateurs are sometimes called "reactive" power dividers as shown in **fig. 1A**. They perform best when all the outputs are well matched in impedance and phase. More on these later.

Another widely used power divider is the isolated type shown in **fig. 1B**. It consists of two transmission lines with an extra port or junction, which absorbs any mismatches on the outputs, and is often referred to as the "Wilkenson" type after its inventor.[9] These power dividers are usually found in low power applications like local oscillator power splitters in transceivers.[6]

The Wilkenson power divider's problem is that it requires an external "floating" load, R_1 in **fig. 1B**, typically 100 ohms in the two-way types. These resistors must have very low reactance and the ability to absorb at least 50 percent of the available input power. A 2-way Wilkenson power divider operating at maximum Amateur power levels would require a 100 ohm 750 watt resistor — not your common everyday flea market item! You can understand why they're not very popular in high power applications.

The loss in power dividers is important, especially in high power applications and high performance antenna arrays. The reactive type in **fig. 1A** has inherently low loss, particularly if the impedance transformer is made from an air (dielectric) line. The Wilkenson type in **fig. 1B** usually has a small loss because of the construction and the isolation load.

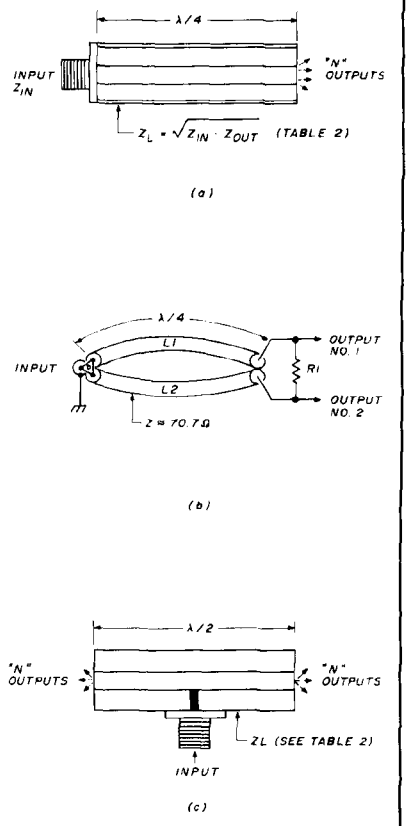


fig. 1. This figure shows the three most common types of power dividers used by Amateurs: (A) The reactive quarter wave impedance transformer type where the impedance is the geometric mean betwen the input and output as explained in the text and as shown in Table 2. (B) The Wilkenson isolated power divider uses two quarter-wavelength transformers. The impedance of L_1 and L_2 are 70.7 ohms and R_1 is 100 ohm for the 2-way version.[9] (C) The "so called" half wavelength power divider is really two quarter-wavelength types connected back-to-back as described in the text.

power divider design

We will concentrate solely on the reactive power divider type shown in **fig. 1A**. The principal of operation is best described as an impedance transformer. At hf, this could be an "L" network but at VHF and UHF it usually consists of a quarter wavelength of transmission line.

The transmission line impedance is the geometric mean impedance between the input and output loads as shown in the equation below:

$$Z_1 = \sqrt{Z_{IN}\, Z_{OUT}} \qquad (1)$$

Where Z_1 is the impedance of the transmission line, Z_{in} is the input impedance, and Z_{out} is the impedance with all the outputs in parallel. For example, in a 50 ohm 2-way power divider design, the output load will be 25 ohms (two 50 ohm lines in parallel) making the required line impedance of the quarter wavelength transformer 35.36 ohms. If a 4-way design is used, the output load will be 12.5 ohms and require a 25 ohm quarter wave line section.

Other power division ratios are also possible (see **table 2**). However, the impedance of the matching transformer of a quarter-wave power divider can get very low, especially when four or more outputs are required. Also, the mechanical problems of co-locating more than four output connectors are formidable, especially on the higher frequencies.

For these and other reasons, two quarter-wave transformers are often connected back-to-back as shown in **fig. 1C**. This is often referred to as a "half-wave power divider"; in reality it is still a quarter-wave type. **Table 2** shows that not only is the impedance of the transformer higher, but the length is twice as long so the phasing lines can be shortened somewhat, decreasing system losses.

The half-wave power divider works on the same principle as the quarter-wave type, but this time the inputs as well as the outputs are in parallel. For instance, if two 4-way quarter-wave types were connected back-to-back, the input impedance would become 25 ohms. To keep a constant 50-ohm impedance throughout, each impedance transformer must transform its outputs to 100 ohms. Thus, when the two transformers are connected in parallel at the input port, the impedance is 50 ohms.

The half-wave power divider has several other properties. In the 2-way type, the impedance of the line is approximately 71 ohms and two standard 70-75 ohm coaxial transmission lines can be used. The 4-way type is even simpler because the impedance of the matching transformer is 50 ohms throughout! (See **table 2.**)

Table 2. The impedance of the transmission line used in common quarter and half wavelength power dividers using 50 ohm input and output impedances.

number of outputs	quarter wavelength	half wavelength
2	35.36	70.71
3	28.87	NA
4	25.00	50
6	20.41	40.82
8	17.68	35.36

simple coaxial power dividers

One of the simplest and lowest-cost power dividers you can build for 6 and 2 meters is the half-wave type using quarter wavelength pieces of standard coaxial cable and "Tee" connectors. I developed them for a commercial antenna company and have used them for almost ten years on my 2-meter EME array. It is relatively small and very flexible, with good VSWR and negligible insertion loss.

Construction details are shown in **fig. 2**. In the 2-way type, the transmission lines are standard RG 11A/U or equivalent coax cable. The 4 way uses standard RG 8A/U, RG 213A/U, or equivalent. Because the dielectric velocity factor of the coax is 66 percent and the coaxial Tee fittings have some finite length and a different dielectric, the lines are shorter than expected in the 2-meter version. Equivalent models can surely be used at higher frequencies, but you may have to experiment with the length of the lines to fully compensate for all the connectors.

A few words are in order on the connectors used for these low cost power dividers. Low cost PL 259s and UHF Tee connectors are usable but not advisable as they are difficult to weatherproof. I recommend weatherproof "N" connectors like the UG21 series and the UG-28A/U Tee connector.

air dielectric power divider construction

In the early 1970s I used copper and brass tubing to make 2-way quarter-wave and 4-way half-wave power dividers. Because they are essentially air dielectric coax, they exhibit very low loss.

To design an air dielectric power divider, first choose the proper transformer impedance from **table 2.** Determine the desired inside diameter of the outer tubing and the outside diameter of the inner tubing (or rod) using the standard equation for a coaxial transmission line as follows:

$$Z_0 = 138 \log b/a \qquad (2)$$

Where Z_0 is the impedance of the line,

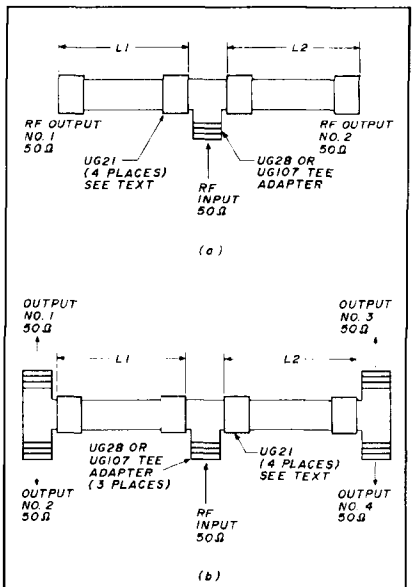


fig. 2. This is an example of simple power dividers made from ordinary coax cable and coaxial adapters. L_1 and L_2 are 58 and 12 1/2 inches long for 50 and 144 MHz, respectively. See text for other frequencies. (A) This is a 2-way power divider. L_1 and L_2 are made from 50 ohm coax such as RG 8 A/U or RG 213 A/U.

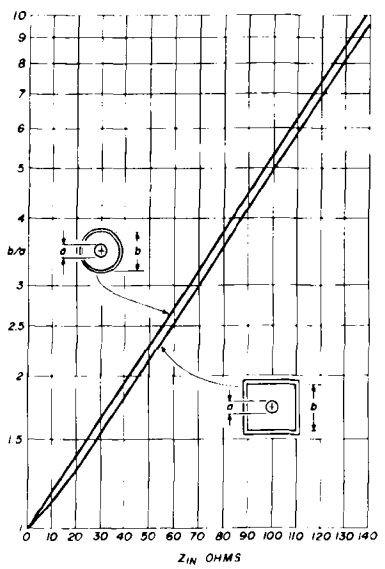


fig. 3. This chart can be used to determine the impedance of an air dielectric coax transmission line made from either round or square outer conductor.

"b" is the inner diameter of the outer tubing and "a" is the outer diameter of the inner line, both in the same units. To simplify calculations, I prepared the graph in **fig. 3** which shows various ratios and their corresponding impedances.

For example, in a 4-way half-wave power divider, the impedance of the line should be 50 ohms (per **table 2**). From the graph or **eqn. 2**, the b/a ratio of the tubing chosen should be approximately 2.3. This can be constructed from brass tubing 9/16 inch inside diameter (5/8 inch outside diameter) and an inner tubing with an outside diameter of approximately 1/4 inch. Although this is an impedance of 48.6 ohms, its maximum VSWR is 1.03:1.

A typical 432-MHz power divider of the type just described is shown in **fig. 4.** It uses brass tubing available at hobby shops or from "Small Parts, Inc."*. It can be adapted for any frequency by changing the distance between the connectors for a quarter wavelength with the following formula:

$$L = 2950/f \qquad (3)$$

* Small Parts, Inc., P.O. Box 381736, Miami, Florida 33238

Where L is a quarter wavelength in inches, and f is frequency in MHz. At 144 and 220 MHz a quarter wavelength would be 20.5 and 13.4 inches, respectively.

I discussed some of the complexities of this divider's construction with Dick Turrin, W2IMU. He fabricated a 432 MHz 2-way power divider using standard type-L copper water pipe, 1/2 inch copper pipe "T" fittings, and a pipe coupling he got from a plumbing supply house.

For the inner conductor he used the copper center conductor from an old defunct 7/8 inch rigid coaxial air line that got contaminated with water, but 5/16 inch brass or copper tubing should be close enough. Details on his 432 MHz 2-way power divider are shown in **fig. 5.**

I recommend this power divider design because it has very low VSWR and insertion loss. Again, the lengths can be adjusted for any frequency with **eqn. 3.** It should also be easy to convert it to a half-wave 4-way type similar to **fig. 4** by placing a pipe "T" at the center junction and using an appropriate center conductor.

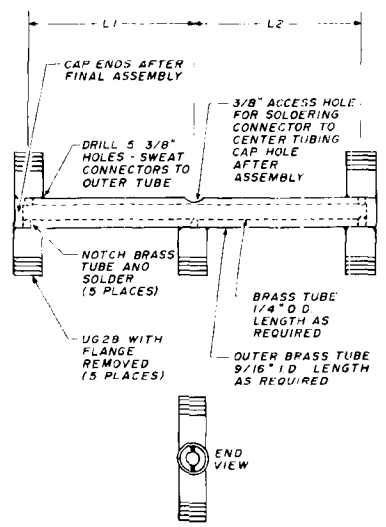


fig. 4. This is an example of a 4-way power divider made from hobby shop or equivalent brass or copper tubing. L_1 and L_2 are 20.5, 13.4, and 6.83 inches for 144, 220, and 432 MHz, respectively.

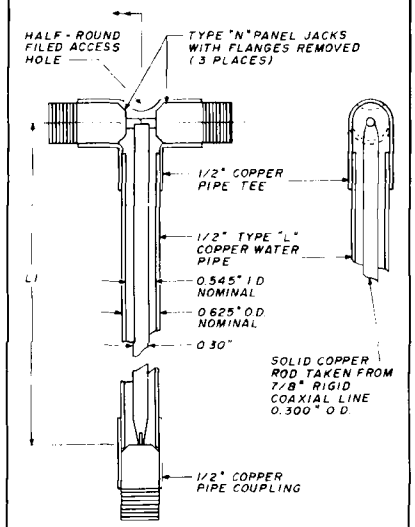


fig. 5. This is an example of a 2-way "plumbers delight" power divider designed by W2IMU. Length L_1 is the same as in fig. 4.

My favorite power divider construction technique uses 1 by 1 inch square tubing with thin (1/16 inch) walls. Some have used thick wall (1/8 inch) tubing but when I tried it, my tap broke through the walls.[10]

Many have avoided constructions with square coaxial transmission line because there have been many conflicting formulas published in Amateur literature. The true formula is found in **reference 11** but is complex and difficult to use. A simple, accurate formula for impedances between 30 and 140 ohms follows:

$$Z_0 = 138 \log ((b/a) \cdot 1.08) \qquad (4)$$

Where Z_0 is the impedance of the line in ohms, "b" is the inside width and "a" is the diameter of the center tubing in the same units. For example, if you use standard 1 by 1 inch square aluminum tubing, it has an inside dimension of 0.875 inches. When used with a center conductor of 13/32 inches outside diameter, you obtain an impedance of 50.6 ohms, close enough for a 4-way half-wave power divider. A graph of this function appears in **fig. 3** using the more accurate formulas from **reference 11.**

A typical 432 MHz 4-way power divider using square outer tubing is shown in **fig. 6**. It uses standard UG 58 type N coax connectors with hobby shop brass for the inner conductor. All connectors are attached by drilling and tapping 4-40 holes in the tubing.

Start by drilling all the connector holes. (I use a Greenlee punch.) Next, drill and tap the connector mounting holes. Don't forget to make a few small "weep" holes on the bottom side of the power divider near the connectors to let moisture escape. Then remove all burrs or metal filings.

If your center conductor material is too short, you can join hobby shop brass by soldering a short piece (2 inches) of the next smaller diameter tubing inside. You can drill a tew small diameter holes in the center tubing where the connectors are attached. Inserting a short piece of No. 14 copper wire aid solder flow to the center pins of the connectors. Finally, seal the ends of the tubing. I prefer to use two layers of 1-inch wide metallic tape which can be removed for periodic checks.

The power divider in **fig. 6** can be redesigned as a 2 way by changing the inner tubing diameter to 9/32 inches. I designed and built a 6-way power divider for 2 meter EME using a 15/32 inch inner tubing diameter with 20.5 inch spacing between connectors. You can use other division numbers by changing the transformer impedance per **table 2**. Similarly, spacing the connectors a quarter wavelength (using **eqn. 3**) will effect a frequency change.

The half wave power divider in **fig. 6** can be converted to a quarter wavelength power divider by removing one side of the divider and using the impedance recommended in **table 2**. A 1296-MHz version is shown in **fig. 7**. It uses most of the mechanical details of the half wave type in **fig. 6**.

some unique power dividers

So far, I have described ordinary quarter and half wavelength power dividers. There are several other techniques or variations also worth mentioning.

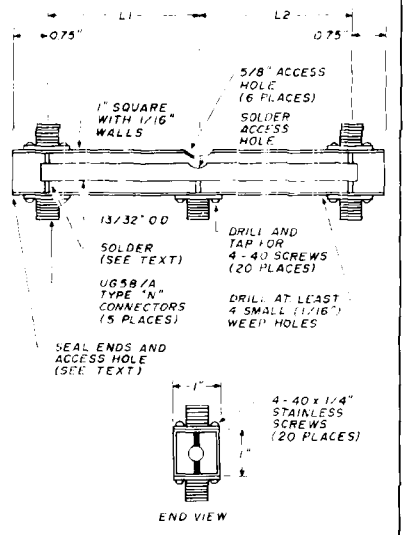


fig. 6. Half wave power divider using square tubing for the outer conductor. The lengths of L_1 and L_2 are the same as in fig. 4.

Although we have concentrated on 50 ohm input and output impedances, there is no reason why a power divider can't be made with different input and /or output values if you choose the proper transformer impedance. For example, antennas could be fed with low loss 75-ohm cable like the CATV type and connected to a 75-ohm output impedance power divider that matches to a 50-ohm transmission line or vice versa. Obviously a 75-ohm input and output impedance is also acceptable if the transformer is modified using **eqn. 1**.

Most power dividers, especially the air dielectric type, will also operate normally at their third harmonic with low VSWR. As mentioned earlier, this will probably allow the phasing lines to be shortened. One possiblity is to use a 144-MHz power divider at 432 MHz. If the tolerances and fabrication are accurate enough, a 432-MHz power divider will operate at 1296 MHz. Other versions are described in **reference 12**.

Several years ago Cliff Schaible, W2CCY, devised a unique 432-MHz power divider composed entirely of standard type N coaxial fittings and adapters (**fig. 8**).[13] These adapters are expensive if purchased new but are reasonably priced and abound at Amateur flea markets. If you have the fittings in your junk box, the whole assembly won't take more than five minutes to construct. The measured VSWR is very acceptable — about 1.1:1.

Reed Fisher, W2CQH, later developed a similar but simpler 4-way power divider for the 23-cm (1296 MHz) band.[14] made up of three type N Tee connectors as shown in **fig. 8B**. Note that the outer adapters are UG 107 A/U, an older and slightly longer version of the more common UG 107 B/U. If you can't find the "A" version, a "B" version can be substituted with slightly higher VSWR.

build or buy your own power divider?

Building a power divider is not difficult if you have access to the necessary materials. As I mentioned earlier, metal parts are available at most hobby shops or through Small Parts, Inc. At least two Amateurs offer parts or kits of parts for power dividers,

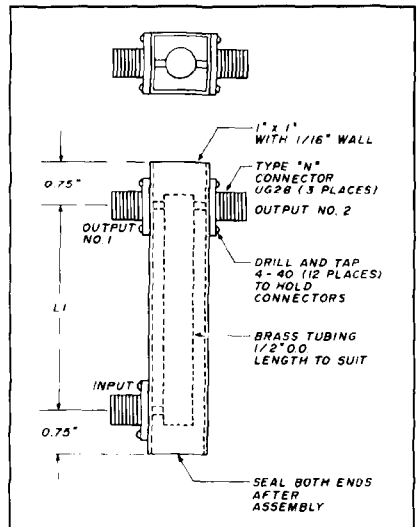


fig. 7. 2-way quarter-wavelength power divider using square tubing. L_1 is 2 1/4 inches for 1296 MHz. For other frequencies see *fig. 4*. Construction follows the same scheme shown in *fig. 6*.

Tom Rutland, K3IPW*, and Charley Byers, K3IWK.**

Most antenna manufacturers offer suitable power dividers. If you prefer to purchase a finished product, check through the advertising section of this and other Amateur publications. Whichever way you choose to go, power dividers should no longer be a mystery.

evaluating your power divider

As we have discusssed, 2- or 4-way power dividers are common in Amateur arrays. The half-wave power dividers, especially the 2- and 4-way types, are preferred because they allow the use of shorter phasing lines.

Although I don't have concrete information to support it, my feeling is that the higher the mismatch at the output end of a power divider, the more likely that array performance will be degraded because the antenna sees a big mismatch when looking into the power divider. In this regard, the 8-way half-wave or the 4-way quarter-wave types are less desirable.

After building or purchasing a power divider, test it before installing it in the antenna system. An easy method for testing power dividers at low power levels is described in **reference 15.**

* Rutland Arrays, 1703 Warren Street, New Cumberland, Pennsylvania 17070

** Byers Chassis, 5120 Harmony Grove Road, Dover, Pennsylvania 17315

First, place a good low-VSWR termination at all power divider output terminals. Next, measure the power divider input VSWR (it should be 1.2:1 or better) and remove one of the terminations. The VSWR should increase. If not, something is wrong with the impedance transformer.

When installing the power divider in the antenna array, mount all the antennas at their final locations with phasing lines in place. For optimum performance the length of the phasing lines should be odd-multiples of a quarter wavelength (see **reference 5**).

Continue by testing each antenna separately. The VSWR should be low, preferably 1.2:1 or better. Then connect all the antennas to the power divider and retest the array VSWR. Don't worry if VSWR increases a bit because the individual antennas may each have a different impedance. Furthermore, there are usually mutual impedance affects in stacked arrays.

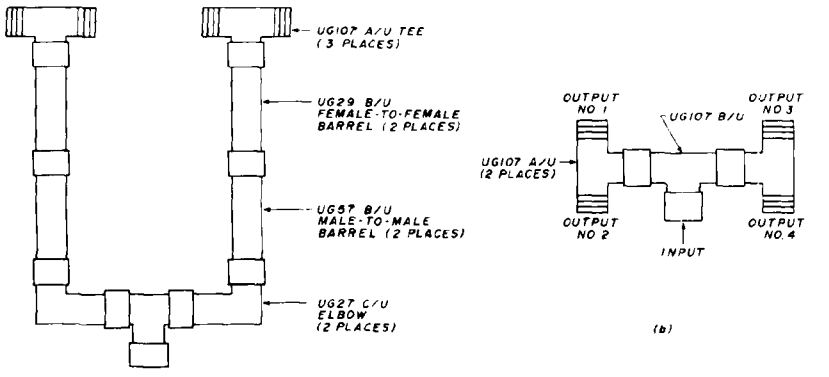


fig. 8. Power divider made completely from coaxial adapters: (A) 4-way for 432 MHz, (B) 4-way for 1296 MHz. See text for further information on the adapters.

summary

This month we discussed different power dividers with emphasis on the more common types Amateurs use. Other power divider configurations are possible and the formulas, graphs, and construction techniques described above should help you design models that meet your needs.

Did I miss any important points? If so, please let me know and we'll discuss them. After all, this is your column!

acknowledgements

I would like to thank Dick Turrin, W2IMU, for letting me publish his "plumbers delight" power divider shown in **fig. 5.**

new records

This has been a record month for new VHF/UHF records. In last month's column I mentioned a new 6-meter EME record. It didn't last very long. On January 5, 1988, Ray Rector, WA4NJP (EM84DG), extended his own EME record on 50.005 MHz to 4470 miles (7193 km) by working Mike Staal, K6MYC/KH6 (BK29AO). Ray was using his same 4 Yagi array and Mike was running a quad array of 10-element 50 foot long Yagis. Both stations were running the legal power level.

On October 18, 1987 at 1945 UTC, the EME contest expedition to the NRAO Greenbank, West Virginia radio telescope set a new 13-cm (2304 MHz) EME record. As W3IWI/8 (FM08CK), they had a 2-way QSO with John Shorland, ZL2AQE (RE78JS), Wellington, New Zealand. The record shattering distance is 8658 miles (13,931 km). W3IWI/8 was using a 150-foot (!) dish and 100 watts while ZL2AQE had a 12-foot dish and 18 watts.

On January 29, 1988, Jay Liebmann, K5JL (EM15DQ), and Gary McCormick, WA5ETV (EM15EM), had what is reported to be the first ever 2-way 33-cm (902 MHz) EME QSO. The distance was approximately 13 miles (21 km). Jay used a 28-foot dish and 150 watts while Gary used a 30-1/2 foot dish and 200 watts. I'll bet this record won't last long!

I'm sorry about the improper listing of the 47-GHz record in February 1988 *ham radio*. I forgot to update the table to include the 13.9 mile (22.4 km) record of WA3RMX/7 and WB7UNU/7 reported in the September 1987 issue. My apologies to Tom and Lyn.

Congratulations to all the new record holders. These are exciting times and it is good to see that the records can always be extended. Keep it up!

important VHF/UHF events:

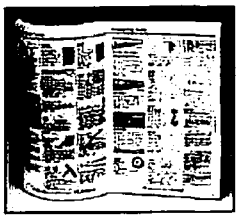
April 29-May 1	*Dayton HamVention*
May 4	*Predicted peak of the Eta Aquarids meteor shower at 1900 UTC*
May 6	*ARRL 902 MHz Spring Sprint Contest (Friday evening local)*
May 10	*EME perigee*
May 12	*ARRL 1296 MHz Spring Sprint Contest (Thursday evening local)*
May 15	*New moon*
May 20-22	*14th Annual Eastern VHF/UHF Conference, Nashua, New Hampshire (contact W1EJ)*
May 21-22	*ARRL 50 MHz Spring Sprint Contest (Saturday evening local)*
May 26	*ARRL 2304 MHz Spring Sprint Contest (Thursday evening local)*
June 4	*EME perigee*
June 7	*Predicted peak of the daytime Arietids meteor shower at 0150 UTC*
June 9	*Predicted peak of the Zeta Perseids meteor shower 1020 UTC*
June 11-13	*ARRL June VHF QSO Party*
June 14	*New moon*
June 21	*± 1 month. Peak of mid-latitude Sporadic E propagation.*

references

1. Joe Reisert, W1JR, "VHF/UHF World: Optimized 2 and 6 Meter Yagis," *ham radio*, May 1987, page 92.
2. Joe Reisert, W1JR, "VHF/UHF World-Yagi Facts and Fallacies," *ham radio*, May 1986, page 103.
3. Joe Reisert, W1JR, "VHF/UHF World-A High-Gain 70 cm Yagi," *ham radio*, December 1986, page 75.
4. Joe Reisert, W1JR, "VHF/UHF World-Stacking Antennas: Part 1," *ham radio*, April 1985, page 129.
5. Joe Reisert, W1JR, "VHF/UHF World-Stacking Antennas: Part 2," *ham radio*, May 1985, page 95.
6. Joe Reisert, W1JR, "VHF/UHF World-33-CM-Our Newest Band," *ham radio*, April 1986, page 83.
7. Joseph H. Reisert, Jr., W6FZJ/1, "VHF Antenna Arrays for High Performance," *QST*, December 1974, page 38.
8. Joe Reisert, W1JR, "VHF/UHF World-Microwave Components and Technology: Part 2, *ham radio*, April 1988, page 67.
9. E.H. Wilkinson, "An N-Way Hybrid Power Divider," *IRE Transactions on Microwave Theory and Techniques*, Volume 8, No. 1 January 1960, page 116.
10. Don Hilliard, W0EYE, "50 ohm Power Dividers," *QST*, October 1973, page 97.
11. Reference Data For Radio Engineers, Howard E. Sams & Co.
12. George Chaney, W5JTL, "Extended Expanded Power Dividers," *ham radio*, October 1984, page 73.
13. Loren Parks, K7AAD, "The W2CCY Quad Yagi Array," *The VHFER*, March 1966, page 6.
14. Reed Fisher, W2COH, "A Successful 1296 MHz Yagi," *ham radio*, May 1972, page 24.
15. Joe Reisert, W1JAA, "Matching Techniques for VHF/UHF Antennas," *ham radio*, July 1976, page 50.

FREE CATALOG!

Features Hard-to-Find Tools and Test Equipment



Jensen's new catalog features hard-to-find precision tools, tool kits, tool cases and test equipment used by ham radio operators, hobbyists, scientists, engineers, laboratories and government agencies. Call or write for your free copy today.

JENSEN® TOOLS INC.

Dept. HR
7815 S. 46th Street
Phoenix, AZ. 85044
(602) 968-6231

147

Hey LOOK !

Your Friends have been talking!

The Secret's Out !

CTM is the ham radio and computer magazine with that "down home flavor", dedicated to the practical aspects of Amateur Communications. Just starting out? You'll find our well-illustrated tutorials friendly and open; we show you how. If your interest is in High Tech, you'll find reviews and user reports of the latest thing to come down the pike and they are written so you can understand them too! If your interest is in training, you'll find articles for ham radio, computers and emergency communications.

You'll find it **ALL** in **CTM**



$18. year U.S. - 6 Months $10.
Mexico & Canada $32. year
Other Countries (air) $68. (Surface) $43.

There is always time for some friendly fun that you don't need a license to enjoy — and appreciate...

Are you into **Packet Radio?** Thinking about it? Then you **definitely** need **CTM!** During 1987 we had **65** packet and packet related articles and that doesn't even count the other **HAM** articles or the many **Computer** articles. The other four ham magazines* only had 26 packet articles during 1987. There's something for everyone in **CTM!** Jump right in, you'll find the natives friendly — and helpful, too!

**NOW which do you need to SUBSCRIBE? CTM of course!*

*CQ™ 5 articles; *Ham Radio*™ 10 articles; *QST*™ 5 articles and *73*™ 6 articles = 26 articles for 1987 for the other ham magazines...

VISA Add 5% for credit cards MasterCard

Name:
Call Sign:
Address:
City: ST ZIP
Phone No. ( )

CTM Magazine
Circulation Manager
1704 Sam Drive
Birmingham, AL 35235
(205) 854-0271

163



DX FORECASTER

Gerth Stonehocker, KØRYW

1987 propagation summary

It wasn't until May 1987 that the necessary 12 months of sunspot data were available to determine when the actual 11-year solar cycle minimum had occurred. A fairly rapid and sustained *increase* thereafter tentatively confirmed September 1986 (SSN-12.3) as the sunspot *minimum* month. Similar data defined June 1986 (flux = 67.6) as the solar cycle *flux* minimum. In light of these two mimima, 1987 can be considered the first year of solar cycle 22.

During 1987 the *sunspot number* increased from 17.4 to about 50 while the *solar flux* increased from 72.5 to 100. Using the superimposed epoch method it is apparent that these increases are comparable to the early rise of cycle 21. This indicates that the new cycle is right on target.

Little solar activity was evident during January, February, and March. Therefore no solar flare-related sudden ionospheric absorption (SID, ultraviolet, and x-ray radiation) occurrences were reported. The geomagnetic field was also quiet during this time (which is normal for the winter season) except for two periods, February 20th-22nd and March 27th. The resulting disturbances were related to coronal transparency and its resulting solar wind particle increase. Midlatitude noontime maximum usable frequencies, MUFs, were around 16 MHz. Solar activity increased in April, and from then through May the level of the geomagnetic disturbances decreased in step with increased solar flux radiation pressure against the earth's magnetosphere. The only reported Sudden Ionospheric Disturbance (SID) was on May 25th. However, the geomagnetic field came alive with a long series of disturbances from May 23rd to June 20th, just as solar flux values were returning to a 27-day minimum. Midlatitude noontime MUFs decreased 27 percent during this period. High latitude and polar signals were also attenuated. The geomagnetic field was not really quiet again until November and December, and then only for a day at a time until December 24th. This is the usual annual scenario. SIDs were reported on July 24th, August 23rd, October 30th, November 6th and 27th, and December 26th. SIDs last only up to one hour or so at the subsolar point on the sunlit side of the earth.

Because of a flare, a medium size geomagnetic disturbance of short duration occurred on July 29th. From August 26th through the end of the year a sizable disturbance was reported every few days. This is unusual because the autumnal equinox is usually a quieter period than the springtime equinox. There were so many disturbances in September that the midlatitude noontime median MUF diminished from 18 to 11 MHz. The MUF decrease during these disturbances was about 8.75 percent of an A unit (geomagnetic index), which is within the sunspot *minimum* relationship discussed in *ham radio*, December 1985. More disturbances as well as visible aurora occurred on August 26th, September 11th and 25th, and November 23rd. These were solar flare-related and each caused a 10 to 15 percent MUF reduction at midlatitude at local noontime. The dozen other disturbances that occurred over this same time frame were due to coronal transparency or changes in the sun's magnetic field structure, which increased the solar wind particle speed and density. This period of increased solar activity and related disturbances was probably caused by rapid changes on the sun as it "heated up" for cycle 22. These disturbances are an indication of what to expect during cycle 22. The next two years will show increased activity, the following two a leveling off at a maximum and, after that, the start of a decreasing trend.

Propagation conditions during this active period will have their ups and downs. An increased number of openings with better signals on 6 and 10 meters are the pluses; lower daytime signal strengths on the lower bands and greater numbers of more intense geomagnetic disturbances causing periods of no high latitude and polar propagation are the minuses. The signal strength and direction variability may increase the possibility for openings to unusual DX locations, making ham radio more fun. Learn to use these minuses in your favor.

last-minute forecast

Expect very good openings on 10 to 30 meters during the second and third weeks of May. This is one of the last months to expect many or very good transequatorial openings before going into the summer season. The best time for these openings will be during medium sized geomagnetic disturbances.

WESTERN USA

GMT	PDT	N	NE	E	SE	S	SW	W	NW
0000	5:00	20	15	15	12	20*	10	10	15
0100	6:00	20	15	15	10	20	10	10	15
0200	7:00	20	15	20	10	20	10	10	15
0300	8:00	20	20	20	10	20	10	10	15
0400	9:00	20	20	20	10	20	10	10	15
0500	10:00	20	20	20	12	20	12	10	15
0600	11:00	15	20	20	12	20	12	12	15
0700	12:00	15	*20*	*20*	15	30	12	12	20
0000	1:00	15	*20*	*20*	*15*	30	15	15	20
0900	2:00	15	*20*	*20*	*20*	30	15	15	20
1000	3:00	20*	*20*	*20*	20	*30*	20	20	20
1100	4:00	*20*	20	*20*	20	*30*	*20*	20	*20*
1200	5:00	*20*	20	15	20	*30*	*20*	*20*	*20*
1300	6:00	*20*	20	15	20	*30*	*20*	*20*	*30*
1400	7:00	20	20	15	20	*30*	*20*	*20*	*30*
1500	6:00	20	20	12	20	20	20	*20*	*30*
1600	9:00	20	20	12	20	20	20	20	20
1700	10:00	20	20	10	20	20	20	20	20
1800	11:00	20	20	10	15	20	15	15	20
1900	12:00	20	20	10	15	20	15	15	20
2000	1:00	20	20	10	15	20	12	12	20
2100	2:00	20	20	12	12	20	12	12	20
2200	3:00	20	15	15	12	20*	12	12	20
2300	4:00	20	15	15	12	15	10	12	20*

MID USA

MDT	N	NE	E	SE	S	SW	W	NW	CDT
6:00	20	15	15	15	20	10	10	15	7:00
7:00	20	15	15	20*	20	10	10	15	8:00
8:00	20	20*	20	20	20	10	10	15	9:00
9:00	20	20	20	20	20	10	10	15	10:00
10:00	20	20	20	20	20	12	12	15	11:00
11:00	20	20	20	20	30	12	12	15	12:00
12:00	20	20	20	20	30	12	15	15	1:00
1:00	20	20	20	20	30	15	15	20	2:00
2:00	*20*	*30*	*20*	*20*	30	15	15	20	3:00
3:00	*20*	*30*	*20*	*20*	*30*	20	20	20	4:00
4:00	*20*	*30*	*20*	*20*	*30*	*20*	*20*	*20*	5:00
5:00	*20*	*30**	*15*	*20*	*30*	*20*	*20*	*20*	6:00
6:00	*20*	20	15	15	*30*	*20*	*20*	*20*	7:00
7:00	20	20	15	15	*30*	*20*	*20*	*30*	8:00
8:00	20	20	12	12	*30*	*20*	*20*	*30*	9:00
9:00	20	20	12	12	20	*20*	*20*	*30*	10:00
10:00	20	20	10	12	20	20	20	*20*	11:00
11:00	20*	20	10	10	20	20	20	20	12:00
12:00	15	20	10	10	20	15	15	20	1:00
1:00	15	20	10	10	20	15	15	20	2:00
2:00	15	20	10	12	20	12	12	20	3:00
3:00	15	20	12	12	20	12	12	20	4:00
4:00	20*	20*	12	15	20	12	10	20	5:00
5:00	20	15	15	15	20	10	10	20*	6:00

EASTERN USA

EDT	N	NE	E	SE	S	SW	W	NW
8:00	20	20	15	15	20	10	10	20*
9:00	20	20	15	20	20	10	10	15
10:00	20	20	20	20	20	10	10	15
11:00	20	20	20	20	20	12	10	15
12:00	20	20	20	20	20	12	12	15
1:00	*20*	20	20	20	30	12	12	15
2:00	*20*	*30*	20	20	30	15	12	15
3:00	*20*	*30*	*20*	20	30	15	15	20
4:00	*20*	*30*	*20*	*20*	30	20	15	20
5:00	*20*	*30*	*20*	*20*	*30*	20	*20*	*20*
6:00	*20*	*30*	*20*	*20*	*30*	*20*	*20*	*20*
7:00	*20*	*30*	*20**	*20*	*30*	*20*	*20*	*20*
8:00	20	20	15	15	*30*	*20*	*20*	*20*
9:00	20	20	15	15	*30*	*20*	*20*	*20*
10:00	20	20	12	15	*30*	*20*	*20*	*20*
11:00	20	20	12	12	20	*20*	*20*	*20*
12:00	20	20	10	12	20	20	*20*	*20*
1:00	15	20	10	10	20	20	20	20
2:00	15	20	10	10	20	15	15	20
3:00	15	20	10	10	20	15	15	20
4:00	15	20	12	12	20	12	12	20
5:00	15	20	12	12	20	12	12	20
6:00	20	20	15	15	20	10	10	20
7:00	20	20	15	15	20	10	10	20*

MAY	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
	ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*"Look at next higher band for possible openings.

These should occur around May 2nd, 11th, 17th, and 24-28th. Toward the end of the month sporadic E short skip openings will probably help higher band DX conditions a little. However, in this early stage of the E_s season the lower bands are expected to have more of these openings. The lower bands are also expected to be very good during the first and fourth weeks, except for local thunderstorm noise during spring storm passages. Enjoy the evenings on these bands, because in another month or so the summertime air mass thunderstorm noise will be upon those of us in the Northern Hemisphere.

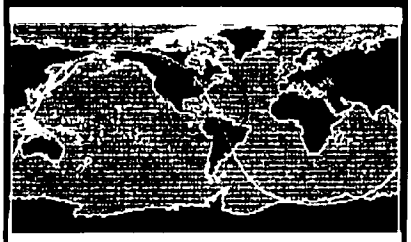
The full moon, of interest to moonbounce DXers, occurs on the 1st and 31st of this month. An Aquarid meteor shower (for meteor-scatter and meteor-burst DXers) peaks between May 4th and 6th, with rates of 10 and 25 per hour for the northern and southern hemispheres, respectively. The lunar perigee is on the 10th.

band-by-band summary

Ten, twelve, fifteen, and twenty meters will support DX propagation from most areas of the world during daylight hours and into the evening, with long skip out to 2000 miles (3500 km) per hop. Signals on the upper three bands arrive mainly from the southern countries and occur near local noontime. Sporadic-E short skip will be available at local noon on some days toward the end of the month. The direction of propagation will follow the sun across the sky: morning to the east, south at midday, and west in the evening.

Thirty, forty, eighty, and one-sixty meters are the nighttime DXers' bands. Because of low solar flux early and late in the month, daytime DX — particularly in the early mornings — may be worthwhile on those days. The direction of propagation follows the darkness path across the sky: evening to the east, north and south around midnight, and toward the west in the predawn hours. Distances will generally decrease to 1000 miles (1600 km) for skip on these bands. Sporadic-E openings will be most frequently observed around sunrise and sunset toward the end of the month.

Satellite Tracking
with your PC and the Kansas City Tracker & Tuner



Hardware and software package for IBM PCs and clones. Automated azimuth and EL-AZ antenna aiming for land, satellite, & EME work.

SATELLITE AND EME WORK
Fully compatible with AMSAT'S QUIKTRAK (3.2) & Silicon Solution's GRAFTRAK (2.0). Preprogram more than 50 satellite passes at one time. We also supply assembled & tested TAPR PSK modems

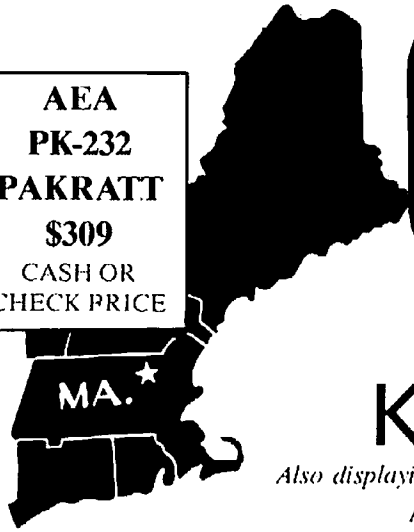
PACKET BBS OPERATORS
VISION-IMPAIRED HAMS
DX, CONTESTS, AND NETS
Special Programs are included for these users

Call or write for our information packet

L.L. Grace
Communications Products
41 Acadia Drive • Voorhees, NJ 08043
(609) 751-1018

168

AEA
PK-232
PAKRATT
$309
CASH OR
CHECK PRICE



TEL-COM
Electronic Communications

NEW ENGLAND'S FACTORY-AUTHORIZED SALES & SERVICE FOR

KENWOOD **ICOM**

Also displaying the popular accessories needed to complete a HAM STATION . . .

ARRL PUBLICATIONS • AEA PRODUCTS • AMPHENOL • ALPHA DELTA • ASTRON • AUSTIN ANTENNAS • AVANTI • BELDEN • BENCHER • B & W • DAIWA • ALINCO • HUSTLER • KLM • LARSEN • MIRAGE • ROHN • TELEX/HY-GAIN • TOKYO HY-POWER LABS • TRAC KEYERS • VIBROPLEX • WELZ • ETC.

167

SONY
ICF-2010
RECEIVER
Air: 116-136 MHz
FM: 76-108 MHz
AM: 150 kHz-30 MHz
$334.95
Cash or Check Price

OPEN SIX DAYS A WEEK MasterCard VISA **WELCOMED**

Telephone 617/486-3400, 3040
675 Great Rd., (Rte. 119) Littleton, MA 01460
1¾ miles from Rte. 495 (Exit 31) toward Groton, Mass.

product
REVIEW

MFJ Model 931 artificial ground

Here's a gadget that's new (but it isn't) and just might be the answer to some problems you may be having. It certainly was a help to me.

I had just changed to one of the new, all digitally controlled hf transceivers. The rig was a dream until a full power linear was put on line. Suddenly there were instability problems in the new rig, even though the antenna was a fairly good match and had been installed for a number of years without incident.

My first attempt at fixing things involved going over the grounding system and improving about as much as I could in an old house that was not wired with Amateur Radio in mind. After doing this, I could use a bit more power before the problems would begin, but the station was still only running at about a quarter of its capability. Frustration was rampant.

Then I remembered a new MFJ product in the other room waiting for review. Called an artificial rf ground, it is basically a modified antenna tuner designed to make a short random length of wire look like a quarter-wave counterpoise. There are just two connections: one to a short wire from the transmitter ground, and the other to a random length of wire thrown on the floor.

The MFJ-931 includes an rf current sensor to help make tune-up a very quick process. Just adjust the tuning capacitor and the inductor tap switch to peak the current reading and you're in business. The whole package comes assembled in a neat metal enclosure that could very easily be mistaken for a modest sized antenna tuner. It should look right at home in the typical ham shack.

Needless to say, this artificial ground was all I needed. Installation took only a minute or so. The new rig immediately settled down and ran just as well as it had before the amplifier was turned on, and peace returned to the household. I do plan to work a bit more on my ground problem and try to eliminate the need for this extra crutch in my station. However, this product certainly gained my respect in the middle of a DX contest, and I will be glad to have it on hand until matters are under better control.

There should be no end to the number of other uses that one could make of this box. Field Day quickly comes to mind along with any other portable or temporary operation, particularly if higher power usage is anticipated. I'll bet that some TVI problems might even be lessened with this interesting little package. How about putting one at the TV set? The possibilities are endless.

I want to point out that using this product does not provide a dc ground for your station. You are still responsible for ensuring that your rig and antenna system are properly grounded for both operator safety and equipment protection. The instructions are clear on this point, and it is to their credit that the manufacturers have not overlooked this most important item. They have also correctly pointed out that at times the counterpoise itself might get rather hot with rf energy. Thus, care must be taken to insulate this lead to protect anyone who might accidently come in touch with it.

The concept of using an indoor quarter-wave counterpoise at the transmitter to act as an rf ground certainly is not new. But as far as I know, the idea of a tuning network specifically designed to accomplish this task easily over the whole Amateur hf spectrum *is* new. From my experience, MFJ-931 is worth consideration by anyone having problems in this area.

W1NLB

Circle #302 on Reader Service Card.

NEW
products

NETWORK 1000 ringrotor

TIC General has introduced the NETWORK 1000 ringrotor antenna mount designed to convert your tower into the axis for networking. It rotates your antenna around rather than above the tower, making it possible to have multiple rotating antennas (with individual rotation ability) on a single tower.

Features include a steel gear drive with 24 VDC gear motor, I-beam ring construction, and positioning to 1 degree. They also manufacture a digital control box designed to work with the ringrotor.

For more information contact TIC General, PO Box 1, Thief River Falls, Minnesota 56701.

Circle #303 on Reader Service Card.

learn Morse Code with your pc

GGTE announces Morse Tutor©, Version 2.1, for learning the International Morse Code or improving code skills.

Morse Tutor is available for IBM PC, XT, AT and equivalents. The program features both Standard (uniform dits, dahs, and spaces) and "FARNSWORTH" (spaces lengthened relative to dits and dahs) methods.

The program introduces each of the letters, numbers, punctuation marks, and special combination characters in 11 lessons. Each lesson features a review of previous current ones, through random character and word drills. Lesson 12 provides random QSO practice of durations up to 10 minutes per QSO.

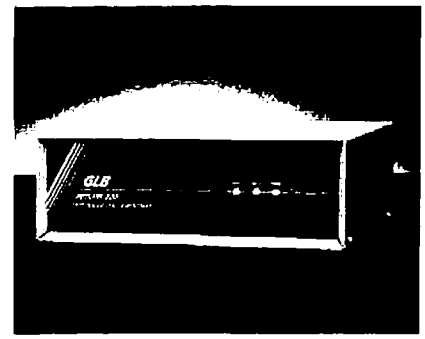
Character display can be selected to occur simultaneously with code sending or after the lesson. A self-calibration utility to control the clock speed of the computer ensures accurate code for speeds ranging from 1 to over 100 words per minute. Morse Tutor provides for setting the tone frequency over the full audible frequency range. All selectible variables — tone frequency, code speed, display mode, and calibration values — are remembered from session to session.

Morse Tutor is $19.95 plus $2.00 for shipping and handling (California residents please add $1.20 sales tax). Order from GGTE, 21881 Summer Circle, Dept. MTH, Huntington Beach, California 92646.

Circle #304 on Reader Service Card.

NETLINK high-speed data transceiver

GLB Electronics has announced a digital-in, digital-out data radio for high-speed packet linking. The NETLINK 220 features 220-225 MHz simplex operation, 2 watts of output and a data rate of 19,200 baud. It is adaptable for use with any node controller that generates and accepts



5-volt CMOS logic levels. It uses the FSK modulation method, requiring a 25-kHz receiver bandwidth at 19,200 baud. Operational temperature range is −30 to +60 degrees C.

NETLINK is compatible with most data formats, including NRZ and NRZI used in packet node controllers. No external clocks or synchronization are needed. Duplicate input-output paths are provided, so that either CMOS (0-5 volts) or RS-232-compatible (+ − 10 volt) signals can be used for data.

With the use of PIN diodes for antenna switching, turnaround time is 1 millisecond making it

possible to use simplex operation at high data rates. To prevent interference through "key clicks", NETLINK uses time sequencing and shaping of the turn-on and turn-off envelopes.

Frequency drift is regulated by oven-controlled crystals and temperature compensated oscillator circuits. A frequency tracking system keeps the signal centered in the receiver passband. The frequency last received is "remembered" between packets; this feature avoids the need to acquire the signal on every transmission.

The receiver uses five large helical resonators for image and out-of-band rejection. A 1-millisecond squelch is available at the rear connector. NETLINK selects filters that achieve good adjacent channel performance with reasonably good phase linearity, and uses a phase correction filter for final waveform correction. Sensitivity is rated at 0.5 uv for a bit error rate of 10^{-3}. The ultimate error rate is better than 10^{-8}.

The transmitter is designed for continuous operation. Six poles of filtering keep adjacent channel interference at a low level. For unattended operation, NETLINK has a key-down timer set to 10 seconds with reset on key-up. Panel LEDs indicate transmitter keying, squelch, and power status. All data and control signals are brought to a DB-25S connector on the rear panel. Additional connections include transmit key, squelch, discriminator, tracking status, and tracking control. NETLINK operates on a 12-volt dc supply wired to an independent jack. The antenna connector is a BNC female. All input-output signals are RFI-filtered, and NETLINK complies with all applicable sections of part 15 of FCC rules. It also has passed tests to part 97 specifications.

The cabinet measures 12 x 10 x 4 inches and weighs 5 pounds, 8 ounces. The list price is $799, $699 Amateur net. For more information contact GLB Electronics, Inc., 151 Commerce Parkway, Buffalo, New York 14224.

Circle #305 on Reader Service Card.

high-power rf amplifier

TIW Systems has announced the addition of the VHP-06 to its existing line of high-power rf amplifiers. With a 40- to 400-MHz bandwidth, 1-watt continuous output, and 44-dB nominal gain (with up to 68-dB gain available by arrangement with the factory), the VHP-06 features a footprint of only 2 x 5 inches, this amplifier utilizes efficient thermal packaging that allows it to operate at 50 degrees C using only convection cooling.



The use of advanced solid-state hybrids allows the VHP-06 to amplify several combined signals while generating few intermodulation products, making this amplifier appropriate for CATV distribution networks, local area network repeater sites, and last-mile distribution of any video or broadband signal. The VHP-06 comes with 75-ohm input and output impedance and a choice of BNC, SMA or "F" type connectors. The amplifier is powered from a user-supplied +24 volt source and draws less than 480 milliamperes. Other impedances and gains may be obtained upon request.

Complete information on the Model VHP-06 is available from Rob Wellins at TIW Systems, Inc., 1284 Geneva Drive, Sunnyvale, California 94089.

Circle #306 on Reader Service Card.

large character environment for computers

Kidsview Software, Inc. has released Kidsview™ and Kidsword™ software transforming the Commodore 64 and 128 into a quadruple-sized character environment for visually impaired and special needs users. Kidsview quadruples character size while closely preserving normal computer operation. The entire contents of the "regular" screen are presented in original order so text continuity is maintained.

Kidsview may be used to write or run programs. Although some commercial software will run, it is intended primarily as a development and display tool.

Kidsword is a large character word processor designed for children, with features making it suitable for more advanced applications. The characters and background change color so that visually impaired users can adjust the screen for maximum comfort and clarity. Kidsword prints large, standard size characters and will be available for the Apple IIe soon. For more information contact Kidsview Software, Inc., P.O. Box 98, Warner, New Hampshire 03278.

Circle #307 on Reader Service Card.

new coaxial cable

Certified Quality RG8X is similar to the RG8X and mini 8 type of coaxial cable introduced by BERKTEK. It has a characteristic impedance of 50 ohms, a 78 percent velocity of propagation, and 95+ percent bare copper shielding over foamed polyethylene dielectric which covers a 16 AWG stranded bare copper center conductor. Its outer diameter is 0.242 inches. The outer jacket is PVC Class I.

Advantages are low cost, high flexibility, light weight, and half the signal loss of RG58 at about the same cost. Limitations are those associated with foamed polyethylene dielectric. It won't stand much heat from any source, and will absorb moisture if not well sealed. In 100 feet, losses at 10 meters are about 1 dB, at 2 meters about 3 dB.

Certified Quality RG8XIIA II has all the characteristics of CQRG8X plus a non-contaminating Class IIA PVC jacket for extended cable life.

Certified Quality 4XL 8 IIA is the latest addition to the "Poor Man's Hardline" class of coaxial cable. It has a non-contaminating Class IIA PVC jacket. Inside is 95 percent coverage tinned copper braid shielding over 100 percent aluminum polyester shield. Semi-solid polyethelene dielectric encloses a 9.5 AWG solid bare copper center conductor. Velocity of propagation is 84 percent, impedance is 50 ohms, and loss figures are about 1.6 dB at 2 meters, 3 dB at 450 MHz, and 4.2 dB at 900 MHz. This class of cable will not withstand constant movement; for some uses a more flexible jumper is indicated.

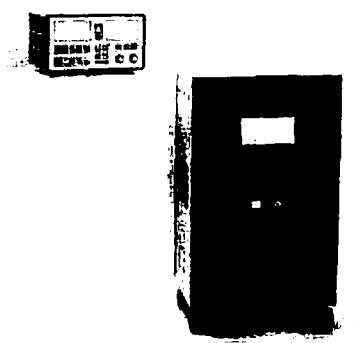
For further information contact "The Wireman", Certified Communications, Pittman Road, Route 2, Landrum, South Carolina 29356.

Circle #308 on Reader Service Card.

high-power linear amplifier

The 230A is a continuous duty linear covering all Amateur bands from 1.8 to 21 MHz (1.8-30 MHz for export). Tuning and protection are controlled by a microprocessor. There is a microcontroller for metering and an rf/power supply deck with remote location capability.

Features include two back-lighted LCD displays, drive power of 50-70 watts, and a built-in SWR computer LDC display readout. The 230A has heavy duty power components, automatic safety monitoring for reverse power, grid and plate current, air flow, filament voltage, and is in compliance with FCC regulations.



The commercial model 230C provides continuous frequency coverage from 1.8 through 30 MHz with a constant duty power output rating of 2250 watts PEP.

For more information contact Advanced Radio Devices, 103 Carpenter Drive, Sterling, Virginia 22170.

Circle #309 on Reader Service Card.

flea market

RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance**. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th ot second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

TEST EQUIPMENT WANTED. Don't wait — we'll pay cash for LATE MODEL HP, Tek, etc. Call Glenn, N7EPK, at Skagitronics Co. (800) 356-TRON.

FOR SALE: Ham Radio Ten-Tec solid state, Model 540, 200 watt transceiver, AC/DC power supply. John Spencer, Fairmont, MN 56031 (507) 238-1621.

DIGITAL AUTOMATIC DISPLAYS. All Radios. GRAND SYSTEMS, POB 2171, Blaine, Washington 98230.

MOTOROLA T45 RTA 860 MHz *Trunking* $450. Several H23, H33, HT 220's VHF low split $100 each. Scott (801) 224-3783.

ANTENNA SPECIALISTS—Astron, Decibel Products, Newmar, Ritron, Shure, TPL, Tripplite, Uniden/Bearcat, Valor. Dealer cost plus 10. DW COMMUNICATIONS. (602) 669-2483

TEN-TEC, Now shipping new boxed latest models 1988 production USA made, 585 Paragon, 561 Corsair II, 229B Antenna Tuner, 425 Titan 1.5 KW amplifier, new model 1 KW Hercules II Mobile/Base Amplifier, 2510 satellite station, TT920 aviation air-band HT plus accessories all models. For best deal write or phone Bill Slep (704) 524-7519. SLEP ELECTRONICS COMPANY, Highway 441, Otto, NC 28763.

HAMLOG COMPUTER PROGRAMS. 17 modules auto-logs, sorts 7-band WAS/DXCC. Full features. Apple $19.95, IBM or CP/M $24.95. KA1AWH, POB 2015, Peabody, MA 01960.

CALL SIGN BADGES: Custom license plate holders. Personal, distinctive. Club discounts. SASE. WB3GND, Box 750, Clinton, MD 20735. (301) 248-7302.

R-390A RECEIVER PARTS: Info SASE. CPRC-26 military Manpack Radio, 6 meter FM, with antenna, crystal, handset: $22.50, $42.50/pair, $97.50/six. Military-spec TS-352 Voltohm/Multimeter, leads, manual: $12.50. $4.50/piece shipping, $9 maximum. Bayttonics, PO Box 591, Sandusky, OH 44870.

75A-4, NC303 WANTED. State model, condition, price and telephone. Bob Mattson, KC2LK, 10 Janewood, Highland, NY 12628.

AM TRANSMITTER WANTED. State model, condition, price and telephone. Bob Mattson, KC2LK, 10 Janewood, Highland, NY 12528.

FOR SALE: Kenwood TS-820S, digital display. Excellent condition, very clean. $475. Matt, WA1HRE, (203) 693-0468.

CHARGE
YOUR CLASSIFIED ADS
to your MC or VISA, write or call
HAM RADIO MAGAZINE
Greenville, NH 03048
(603) 878-1441

PROFESSIONAL QUALITY DTMF Decoder and Select Call System, by Vince Yakamavich, AA4MY, see Feb QST Magazine for details. Blank board #152-PCB only $17.95. Kit of Parts including board, #152-KIT only $69.95. Assembled and tested board #152-ASY only $99.95. Add $2.50 per order S/H. A & A ENGINEERING, 2521 W. LaPalma, Unit K, Anaheim, CA 92801. (714) 952-2114.

WANTED Rohn 25G sections (5 or more), guys, guy grips, turnbuckles, insulators, etc. LDF5-50 heliax plus connectors up to 250 ft. Will pick up within 150 miles of Huntsville, AL. HAM-M or Ham-VI will pay shipping. Robert Walls, 128 Dollywood Drive, Toney, AL 35773 (205) 828-6738.

PROGRAMMER for single component microcomputer. Learn to program, control circuits, generate wave forms. SASE details. DELL COMMUNICATIONS, 538 Griscom Drive, Woodbury, NJ 08096.

SB220 OWNERS: Add 160 meters, QSK, +8 additional enhancements. 40 page step by step manual includes parts sources, and 3-500z tech manual. SASE for details. $10 plus $1 postage. WA2SQQ, 69 Memorial Place, Elmwood Park, NJ 07407.

ANALOG AND RF CONSULTING for the San Francisco Bay area. Commercial and military circuits and systems. James Long, Ph.D., N6YB (408) 733-8329.

COMMODORE/AMIGA CUSTOM CHIPS FOR C64/128 Computer/peripherals at low prices. 24 hour delivery. #6510- $9.95, #6526- $9.95, #6567- $14.75, #6581- $12.85, PLA- $12.50, 901 ROMS at $10.95 each and many others *including Amiga..."The* COMMODORE DIAGNOSTICIAN". A complete diagnostic reference chart for fixing Commodore computers, etc. An absolute must for those who want to fix their own computers and save money and downtime. $6.95 plus $1.00 postage .. COMMODORE REPAIR. We are the largest/oldest Authorized Service Center in the country. (eg. C64- $39.95). Fast turnaround. Heavy duty Power Supply for C64- $27.95 plus UPS. Send for complete chips/parts catalog...VISA/MC...Kasara, Inc., 36 Murray Hill Drive, Spring Valley, NY 10977. 1 800-642 7634, 800-248-2983 (outside NY) or 914-356-3131.

WANTED: Klystron tubes especially 2911; Magnatrons; also 304TL, 6012, 810 and 5CX1500A. All types of sockets for transmitting tubes. Harold Bramstedt, 6104 Egg Lk Rd, Hugo, MN 55038. (612) 429-9397.

UHF PARTS, GaAs fets, mimics, chip caps, trimmer caps, and other builder parts. MGF 1402 @$14.00. MFG 1302 @$10.00. .8-10pf Trimtronics trimmer @$3.75. Porcelain chip caps @$1.75. Orders add $1.00 p + h. SASE for complete list. MICROWAVE COMPONENTS, 11216 Cape Cod, Taylor, MI 48180.

WA9GFR COMMUNICATIONS SOFTWARE. $15.00 disk contains *HF/VHF/UHF/L-Band propagation programs to predict* range in miles based on transmitter power, receiver sensitivity, and antenna height & gain. A "must" for designing repeater installations. Also includes Smith Chart impedance matching programs. Commodore-64 or IBM. Lynn Gerig, RR1, Monroeville, IN 46773.

BM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

JENNINGS UCS-300-7.5 KV variable vacuum capacitor $135, RJ1A/HC-1 vacuum relay $75, RJ2C $140. Cardwell 2100pF-3 KV variable capacitor $45. Eimac 3CX1200A7 $375, 4CX3,000A $675, 4CX5,000A $950, SK-2210/SK-2216 $85. Centralab 858-1000pF $5 ea. (All new). A. Emerald, 8956 Swallow, Ftn. Vly, CA 92708 (714) 962-5940.

RTTY JOURNAL—Now in our 36th year. Read about RTTY, AMTOR, PACKET, MSO'S, RTTY CONTESTING, RTTY DX and much more. Year's subscription to RTTY JOURNAL $10.00, foreign slightly higher. Order from: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

MARCO: Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224. (213) 774-1255.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC. ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

OHIO: April 29. The 19th Annual B*A*S*H will be held on Friday night of the Hamvention at the Conference Center (Madison Room) of the HARA ARENA AND CONFERENCE CENTER, (the same location as the Hamvention), starting at 7:00 PM. There is no admission charge, and free continuous entertainment. Hot dinner, sandwichs, snacks and beverages are available. Two exciting top awards, and many others. Stay right at HARA when the Hamvention closes on Friday evening and meet your friends and join us for an evening of fun and entertainment. Sponsored by the Miami Valley F.M. Association, PO Box 263, Dayton, Ohio 45401.

ARIZONA: April 30-Mey 1. The Cochise Amateur Radio Association (CARA) will hold its 1988 Hamfest at the club's training facility, south Moson Road and Rt 90, Sierra Vista. VE exams, free tailgating. Talk in on 146.16/76 or 146.52. For more information contact Steve Wagner, W7CI (602) 458-6946 or CARA, PO Box 1855, Sierra Vista, AZ 85636.

FLORIDA: May 8. SPARC, the St. Petersburg ARC is sponsoring a Hamfest. Lake Maggiorie Park, Shelter 1 and 2, Ninth Sts and Lake Maggorie, St. Petersburg. 8 AM to 3 PM. Free admission. Free swap tables. Talk in on 147.06/66. Contact Hank Briese, WA4RLV, 10804—84th Avenue N., Seminole, FL 34642.

OHIO: May 8. Medina County Hamfest, sponsored by the Medina 2 Meter Group. 8 AM to 2 PM. Medina County Community Center, 735 Lafayette Road, Medina. Donations $4.00/door; $3.00/advance. Vendor tables $6.00. Setup 6 AM. Mobile check in 147.63/03 K8TV/R. Free parking. Medina Hamfest Committee, PO Box 452, Medina. OH 44258.

OKLAHOMA: May 14 and 15. The 1988 Green Country Hamfest, sponsored by the Broken Arrow and Tulsa ARCs, Tulsa State Fairgrounds Pavilion. 9 AM to 5 PM Saturday and 8 AM to 4 PM Sunday. All indoors flea market and dealer exhibits, programs, exams. Nearby Amusement Park. Evening family BBQ affordably priced at $7.00. Blue Grass band entertainment. Preregistration $6. $8 at the door. Flea market tables $7.50 advance; $10/door. Children under 12 free. For information contact Ron Gamel, N5WX (918) 663-0385 or write Green Country Hamfest, PO Box 4283. Tulsa, OK 74159.

ILLINOIS: May 15. The Knox County Radio Club will hold its annual Knox County Hamfest, Knox County Fairgrounds, Knoxville. Large outdoor flea market area space available at no charge. Opens 7 AM. Indoor commercial opens 8 AM. VE exams on site. Knox County Pork Producers will serve their famous Butterfly pork chops and more. Talk in on 147.00/146.40. For table reservations, exam registration and tickets write Keith L. Watson, WB9KHL, 119 South Cherry Street #3, Galesburg, IL 61401-4527 or call (309) 342-3885 evenings.

OHIO: May 15. The Athens County Amateur Radio Association's ninth annual Hamfest, City Recreation Center, East State Street, Athens. 8 AM to 3 PM. Admission $4.00. All level license exams. Send completed 610, $4.55 check payable to ARRL/VEC to John Cornwell, NC8V, 101 Coventry Lane, Athens, Ohio 45701. Walkins accepted. Free paved flea market. Indoor space advance registration only. Contact Rod Holley, **KA8NDC**, 15267 S. Canaan Rd, Athens, Ohio 45701. (614) 593-8177. Talk in on club repeater 146.34/.94. For general information Carl J. Denbow, KA8JXG, 63 Morris Avenue, Athens. Ohio 45701.

NEW YORK: May 15. LIMARC ARRL Long Island Hamfair, New York Institute of Technology, Rt 25A/Northern Blvd, Old Westbury, NY. Outdoor tailgating $5.00/car space. General admission $3.00. Non-Ham spouse and children admitted free. Open 7:30 AM for sellers; 9 AM for buyers. Food, refreshments available. For more information call Hank Wener, WB2ALW (516) 484-4322 or Mark Nadel, NK2T (516) 796-2366.

ILLINOIS: May 15. Chicago ARC's annual Mini-Hamfest, North Park Village, 5801 N. Pulaski, Chicago. Admission $2. 9 AM to 3 PM. Refreshments. For information call 545-3622.

PENNSYLVANIA: May 15. The Warminster ARC's 14th annual Hamfest, Middletown Grange Fairgrounds, Penns Park Road, Wrightstown. Gates open 7 AM. Vendors 6 AM. Admission $3.00. Indoor 8' tables $5.00/space. Unlimited outdoor space $5.00/space. Talk in 146.52 simplex. 147.69/09 repeater. For information or pre-registration contact Frank Charlton, KA3FBP, 1479 Kingsley Drive, Warminster, PA 18974. (215) 675-2649.

PENNSYLVANIA: May 15. 10th annual Hamfest sponsored by the Tioga County Amateur Radio Club, Tioga County Fairgrounds, Whitneyville. 8 AM to 4 PM. Gate admission $3.00. Advance $2.50. Inside tables $3.00. Outdoor flea market free. VE testing. For advance tickets send check or MO with #10 SASE to Bill Reilly, RD 4, Box 103, Wellsboro, PA 16901. Deadline May 1, 1988. Talk in on 146.79 or 146.52 simplex. For more information John Winkler, WB3GPY, RD 2, Box 267, Wellsboro, PA 16901.

ILLINOIS: Kankakee. May 15. The annual Kankakee Hamfest, sponsored by the Kankakee Area Radio Society *will be held at* the Kankakee County Fairgrounds from 8 AM to 3 PM. Free flea market tables (limited) and many exhibitors. ARRL Booth. Free

parking. Food and drinks available. Admission $2.50 advance, $3.00 at the door. Setup May 14 6 PM to 8 PM and May 15 6 AM to 8 AM. Talk in on 146.34/94. More information from KARS c/o Frank DalCanton, KA9PWW, RR 1, Box 361, Chebanse, Illinois 60922. Tel 815-932-6703 after 5 PM CST or 815-937-2452 before 5 PM CST.

MICHIGAN: May 21. Swap & Shop sponsored by the Wexaukee ARC. NEW LOCATION- Cadillac Middle School, 500 Chestnut Street, Cadillac. 8:30 AM to 3 PM. Admission $3.00. Tables $6.00. Guest speaker, Doug DeMaw, W1FB. Contact John Craddock, KX8Z (616) 797-5491 or write Wexaukee ARC, PO Box 163, Cadillac, MI 49601.

COLORADO: May 21. The Pikes Peak Radio Amateur Association's Swapfest, Rustic Hills Mall, Palmer Park and Academy Blvd, Colorado Springs. 8:30 AM. Free admission. Tables $8.00/advance; $10.00/door. VE exams. Talk in on 146.37/97. For information or reservations contact Al, N0CMW (303) 473-1660 or write PPRAA Swapfest, PO Box 16521, Colorado Springs, CO 80935.

TEXAS: May 21. Armed Forces Day. The Key City ARC will hold its annual Ham Radio/Computer Swapfest, Abilene Civic Center, Pine Street, downtown Abilene. 8 AM to 5 PM. Friday night 6 to 11 PM Dealer Setup. Pre-registration $5; $6/door. Tables $2.00 each. Non-ham spouses and children under 12 admitted free. Ham breakfast Saturday morning 6 AM to 7:45 AM. Texas Bar-B-Que 7:30 PM, Abilene Inn. FCC exams. Talk in on 146.800. For information contact Bill Jones, N5DOX (915) 698-4606. Send pre-registrations to RCARC, Box 2722, Abilene, TX 79604 or call me on 14.090 RTTY during the day.

NEBRASKA: May 20, 21, 22. The 1988 Midwest Division ARRL Convention, Marina Inn, So. Sioux City. Friday night get-acquainted dinner with entertainment. Saturday activities start 8 AM. Exhibitors and large flea market. DX, Packet, Computers, Handi-Hams, RTTY, AMTOR. FCC exams Sunday AM. Flea market info Al Smith, W0PEX, 3529 Douglas St, Sioux City, Iowa 51104. Convention info Dick Pitner, W0FZO, 2931 Pierce St, Sioux City, Iowa 51104.

ARKANSAS: May 21. The Northwest Arkansas ARC's annual Hamfest, Rodeo Center, East Emma Avenue, Hwy 68B, Springdale. 8 AM to 4 PM. Setup 6 AM. Exhibits, swap tables, snack bar, VEC exams, forums, programs, etc. Reserved tables $3.00 each. Talk in on 146.76. For information or tables contact Chuck Webb, KA5BML or Mary Webb, KA5HEV, PO Box 338, Prairie Grove, AR 72753. (501) 846-2847.

NEW HAMPSHIRE: May 20-22. The 14th Annual Eastern VHF/UHF/SHF Conference, Rivier College, Nashua. Sponsored by the Northeast VHF Association. Chairman Thomas Kirby, W1EJ. Friday night hospitality room including swap-fest, tech talks on Saturday. Housing available in dormitories. For information, reservations, etc contact Lewis D. Collins, W1GXT, Publicity Chairmen, Eastern VHF/UHF/SHF Conference, 10 Marshall Terrace, Wayland, MA 01778. (617) 358-2854 (6 to 10 PM EST)

NEW YORK: May 27 and 28. The 2nd annual SKANFEST, Ham Radio and Computers, Allyn Arena, Skaneateles. Indoor/outdoor setup Friday, Noon to 6 PM. Open Saturday 9 AM to 5 PM. Flea markets, indoor commercial vendors, tech sessions and more. Advance admission $2.50, gate $3.00; outdoor flea market $2.50/space; gate $3.00; indoor flea market $8.00/8' table; gate $10.00. Talk in on 147.00/146.40 and 442.30 repeaters. For more info call Hank Bryant (315) 685-7658. Advanced tickets SKANFEST, PO Box 302, Skaneateles, NY 13152. Deadline May 13.

ONTARIO: June 4. Amateur Radio Flea Market sponsored by the Guelph ARC and the Kitchener-Waterloo ARC, Bingeman Park, 1380 Victoria Street North, Kitchener. 8 AM to 2 PM. Vendors 6 AM. Admission $3.00. Children 12 and under admitted free. Vendors table rentals $5/8' space. Talk in on 146.37, 146.97, 144.61, 145.21, 52/52 simplex. For tickets or table reservations contact Ray Jennings, VE3CZE, Co-Chairman, 81 Ottawa Crescent, Guelph, Ontario N1E 2A8 (519) 822-8342.

MICHIGAN: June 5. The 11th annual Chelsea Swap 'N Shop, Chelsea Fairgrounds. Donation $2.50 advance; $3.00/door. 8' table space $8.00. Trunk sales $2.00/space. Handicap parking. Food available. Nearby campgrounds. For information Robert Schantz, 416 Wilkinson Street, Chelsea, MI 48118. (313) 475-1795.

CONNECTICUT: June 5. The 4th annual NARL Flea Market, sponsored by the Newington Amateur Radio League, Newington High School, Rt 173, Newington. Tours of ARRL Headquarters and W1AW, exams, refreshments. Ham and computer gear for sale. Talk in on 146.52, 144.85/5.45 and 223.24/4.84. For information SASE to Les Andrew, KA1KRP, 23 Grove St, West Hartford, CT 06110. (203) 523-0453.

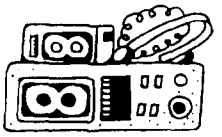
PENNSYLVANIA: June 5. The 34th annual Breeze Shooters Hamfest, White Swan Amusement Park, Rt 60, near Greater Pittsburgh International Airport. 9 AM to 4 PM. Free admission, free parking, free tailgating. Family amusement park. Registration $2.00 each; 3/$5.00; 7/$10. For additional information call Jim Inverarity, K3TOQ, 2639 Sunnyfield Drive, Pittsburgh, PA 15241. (412) 833-2681.

VIRGINIA: June 5. Manassas. The Ole Virginia Hams present the annual Manassas Hamfest and Computer Show the the Prince William County Fairgrounds, 8 AM to 4 PM. General admission $5.00. Children under 12 admitted free. Tailgating $6.00/space. Special activities include non-ham programs, ARRL booth and CW proficiency awards. Talk in on 146.37/97, 146.52. Dealers contact Joe Schlatter, K4FPT (703) 368*8569 evenings or Randy Moler, KA4UFF (703) 791-3061. For information write Ole Virginia Hams ARC, PO Box 1255, Manassas, VA 22110 or call Jack Gunsett, KI4VP (703) 361-5255.

COLORADO: June 10 and 11. The tenth annual Superfest sponsored by the Northern Colorado ARC, Larimer County Fairgrounds, Loveland. 5 PM to 9 PM Friday and 8 AM to 5 PM Saturday. Dealer setup all day Friday. VEC exams Saturday. Refreshments available both days. For information contact Exhibits Chairman Bud Hayes, W0JFN, 3109 N. Douglas, Loveland, CO 80537 (303) 663-3119.

NORTH CAROLINA: June 11. Winston Salem Hamfest & Computer Electronics Fair '88. Sponsored by the Forsyth ARC. Dixie Classic Fairgrounds, Winston-Salem. Admission $4/advance; $5/door. Food, indoor dealer area. FCC exams. Contact Bob Gates, KJ4IC, Box 60, Cedar Grove Park, Kernersville, NC 27284. Plenty of flea market/tailgating space and free parking. Talk in on 146.04/64. For pre-registration SASE to Dave Ward, KA1LVO, 5573 Vienna-Dozier Rd, Pfafftown, NC 27040. Dealer info Jim Rodgers, N1DRI, Box 11234, Winston-Salem, NC 27116 (919) 760-2493).

INDIANA: June 12. "Summerfest" sponsored by the Michiana ARC, University of Notre Dame Athletic and Convocation Center, South Bend. Exhibits, FCC exams walkins, shows. For reservations or information call Joe Mergen, N9GID (219) 258-0057 or (219) 258-0577. Write to: 2030 Trailridge North, Mishawaka, IN 46544.



OPERATING EVENTS
"Things to do . . ."

May 14. *SARA will operate K2AE from* Saratoga Spa State Park, Schenectady during the Boy Scouts of America North-O-Ree III. 1300 to 2000Z. 14.330 and 28.360. For commemorative QSL send QSL and SASE to WB2STS, 2 Union Street, Schenectady, NY 12305.

May 14 and 15. The Uniontown ARC will operate W3PIE, 1700 to 0300Z both days to commemorate the 50th anniversary of U.A.R.C./W3PIE. For certificate send QSL and large SASE to Uniontown ARC, c/o John Cermak, Box 433, Republic, PA 15475.

May 21: The 39th annual Armed Forces Day Communication Test. CW, SSB, RTTY and Packet.

May 21: The Maryland Mobileers ARC will again operate its annual Special Events Station aboard the U.S. Submarine Torsk, Pier 3, Baltimore Inner Harbor. 9:30 AM to 4 PM EST. The Mobileers have chosen Armed Forces Day to honor the Submarine Service. The public is invited to come aboard and watch the Hams in action.

May 21-22: The St. Charles ARC will operate Special Event Station WB0HSI from 1300Z to 2100Z as part of the Lewis and Clark Rendezvous. 7250, 14325, 21350, 28410 and 146.67. For certificates send large SASE to the St. Charles ARC, PO Box 1429, St. Charles, MO 63302-1429.

May 21: The Great River ARC of Dubuque, Iowa will operate NSOU from 1500Z to 2200Z at the site of the annual Dubuquefest Special Events and Message Center. Lower 20 kHz of 75, 40, 20 and 15m General bands. Novice band station N9FVN voice 10m. For QSL card SASE to NSOU, 2735 Hickory Hill, Dubuque, Iowa 52001

May 28-June 3. The Palmetto ARC will operate club station W4MN as W2OOMN to celebrate the Bicentennial of the US Constitution from the historic South Carolina state capital, Columbia. Operation on all bands with SSB, CW and RTTY during this week. For a special commerative QSL send large SASE and QSL via W4MN, Palmetto ARC, 625 Spring Lake Rd, Columbia, SC 29206.

May 28: Members of the Bay Area ARS will operate Special Event station N3EKZ to commemorate the transmission of the telegraph message, "What Hath God Wrought" send on an experimental line from Washington to Baltimore 144 years ago. For a special commemorative certificate send QSL card, SWL send details of QSO, with large SASE to the Bay Area ARS, PO Box 805, Pasadena, MD 21122-0005.

June 6 to June 12: The Ascension Amateur Radio Club will hold its annual Jambalaya Festival Special Event, 1500Z to 2359Z daily on 20, 15 and 10m bands. Special event package contains three Jambalaya Recipes. Send $1.00 to cover postage and mailers, QSL card with calls of stations worked to AARC, PO Box 278, Sorrento, LA 70778-0278.

THE FOUNDATION FOR AMATEUR RADIO, INC plans to award twenty-eight scholarships for academic year 1988-89 to assist licensed Radio Amateurs who plan to pursue a full-time course of study beyond high school and are enrolled or have been accepted by an accredited university, college or technical school. For further information write FAR Scholarships, 6903 Rhode Island avenue, College Park, MD 20740 prior to May 31, 1988.

HAM EXAMS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday MAY 18, 7 PM, MIT Room 1-150, 77 Mass Ave, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 646-1641. Exam fee $4.50. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 available from the FCC in Quincy, MA (617) 770-4023.

ALL BAND TRAP VERTICAL ANTENNAS!

FULL 1/4th WAVE - All Bands! Automatic Selection with proven HI-Q Traps. 5 Models-ALL self supporting - Ground or roof mount. HI STRENGTH FIBERGLASS TUBING OVER - ALL NO WOBBLY, LUMPY TRAPS - NO UNSIGHTLY CLAMPS needed - Size 1 1/4" all the way up - Traps hidden inside. You can use it in a 1 ft. sq. Backyard! FOR APARTMENTS, MOBILE HOMES - CONDOS etc. where minimum space and neat appearance is MANDATORY! Instant "Drive In" ground mount (included) Use with or without radials (included) (All angle roof mount - Extra) COMPLETELY PRETUNED - NO ADJUSTMENTS NEEDED EVER! NO TUNER NEEDED FOR MOST TRANSCEIVERS! Use - RG8U feedline, any length! 2000 Watt PEP input power. Shipped - PREPAID IN USA Assembles in 10 min. using only screwdriver WEATHERPROOF!

No - AVT80-10	5 Band	25'6"	$199.95
No - AVT40-10	4 Band	18'9"	$139.95
No - AVT20-10	3 Band	11'4"	$109.95
No - AVT80-10W	8 Band	22'	$299.95
No - AVT40-10W	7 Band	15'9"	$259.95

SEND FULL PRICE FOR PP DEL IN USA (Canada is $10.00 extra for postage, clerical, Customs) or order using VISA, MASTER CARD or AMER-EXP. Ph 1-308-236-5333 9AM-6PM weekdays. We ship in 2-3 days. All Antennas Guaranteed for 1 year -10 day money back trial. Free Int'

WESTERN ELECTRONICS
Dept. AH Kearney Ne. 68847

✓ 206

MOVING?
KEEP HAM RADIO COMING . . .

If possible let us know four to six weeks before you move and we will make sure your HAM RADIO Magazine arrives on schedule. Just remove the mailing label from this magazine and affix below. Then complete your new address (or any other corrections) in the space provided and we'll take care of the rest.

ham radio Magazine
Greenville, NH 03048

Allow 4-6 weeks for correction.

Thanks for helping us to serve you better.

Here's my new address:
Call ____
Name ____
Address ____
City ____ State ____ Zip ____

AFFIX LABEL HERE

We've Got Books
Plenty of Books

Send SASE for free flyer

Ham Radio's Bookstore
Greenville, N. H. 03048



ELMER's NOTEBOOK

Tom McMullen, W1SL

This is antenna month, both in *ham radio* magazine and in backyards all across the country. For many Amateurs, it's a time to try some of the ideas that were chewed over during the cold, short days and long nights of the past winter. For others, it's a time to assess the skywire's readiness to start on the next season's DX or rag-chewing. Whatever the reason, antennas are an endlessly popular subject in Amateur Radio circles, so I'll add a few thoughts.

ideal antennas

There are certain truisms in the radio world that are hard to argue with: "a big antenna is better than a small one," or, "a high antenna grabs DX better than a low one," and "a rotary beam antenna is more versatile than a fixed dipole."

Along with these truths is the feeling that one should have limitless backyard acreage available in which to put these marvels of wire, insulation, tubing, and tower. Does a ham exist who hasn't dreamed of two perfectly spaced tall trees that an 80 (or 40, 160, or whatever) meter dipole will fit between nicely? Or how about that sight for sore eyes, the 100+ foot tower gleaming in its nest of guy wires with half of Alcoa's stock of tubing on the top, waiting to whirl to a bearing for that rare one? Sad to say, far too many hams are faced with the same pressures for space as the rest of the population. In many parts of highly populated urban America, real estate people tout 70 by 130 feet as a "large" lot! And it usually has power lines across one or both ends; this further reduces the options for antenna-izing.

antennas for the real world

The view is not too bleak, however. Amateur Radio can and does thrive in cramped neighborhoods — some that, by comparison, make 70 by 130 seem like a really large lot.

A look at a few antenna fundamentals will help you find a way to put up a working skywire.

First, note that the portion of the antenna that carries the heaviest current does the work. Current flow, whether dc, ac, or rf, is the major energy-transfer medium. With an ideal center-fed antenna, placed high in the clear, the current flow in the center produces a magnetic field that surrounds the wire. If you could see the rf, a sight down the wire from one end would show you a doughnut-shaped field expanding in all directions. Anything above the horizon would keep on going out of sight, and the field that intercepts the earth (or houses, wiring, and trees) would bend and reflect in ways that are sometimes difficult to predict.

A vertical antenna (like a quarter wave with many ground radials at its base) also has a magnetic field around it, but the "doughnut" is on its side at the base of the antenna — and much of it actually intercepts the earth and ground system. It is this interception and reflection from nearby "ground" that cause a large portion of the radiation to depart the vicinity at a considerable angle above the horizon. Not to worry: the atmosphere is full of layers of ionized gas just waiting to bend the waves back down to earth, and often there's another Amateur at the other end of the specific ray path!

Much can be done with these simple antennas if you remember some basics: the high-voltage end(s) must be well insulated; and any vertical, especially the shorter ones, must have a ground system of some sort to work against. Let's look at a few examples.

the nonhorizontal dipole

This type of antenna, shown in **fig. 1**, has been called a "sloper" in many publications. It is simply a center-fed half-wave antenna suspended between two convenient supports (in this case, the top of a house and a section of mast anchored to a fence post). The high end can be anything you can reach to hook the antenna on — a tree, an attic window, a telescoping tower made of tubing sections, whatever. *Never, never* use any part of nearby power line poles for your support! All antenna installations should be carefully planned so there's no chance of any accidental contact with power wiring; that includes the entrance wiring to your house.

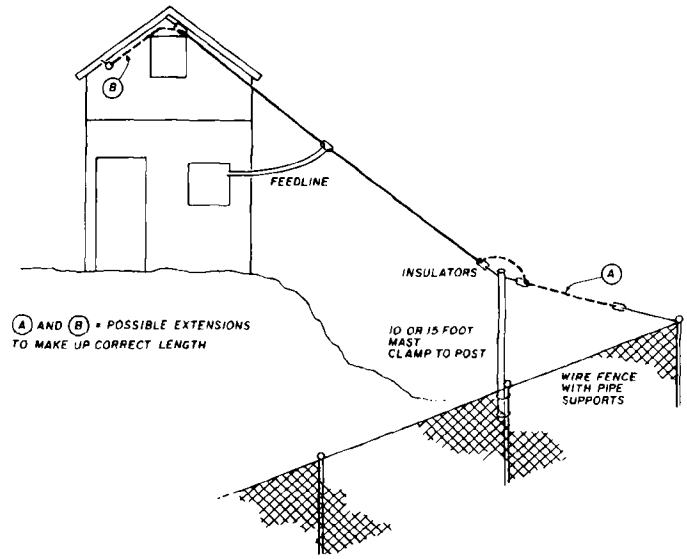


fig. 1. An antenna can be suspended between a tall object, such as a roof peak or high window, and a lower one that is a convenient distance away. Extensions can be added to gain a few more feet if needed, as shown by dotted lines A and B.

The antenna in **fig. 1** is center fed with either a coaxial cable and a balun, or by twin lead. If you use twin lead or ladder line, you'll need either a Transmatch or a balun transformer at the transmitter end to provide a balanced feed.

You have a couple of options if the space is too short to support a half-wave antenna on the band you want to operate. Putting in some loading coils will physically shorten it while still providing an electrical half wave. These coils make the antenna resonant, so it will absorb and radiate power almost as well as if it were full length. Many antenna manuals and handbooks describe how to make simple loading coils wound around porcelain insulators or plastic rods, but you can find them in magazine advertisements or at hamfest flea markets.

Another option is to bend the antenna a bit. You'll want to support as much of the current-carrying part of the wire as high and clear as possible, and let the ends run off at the angle necessary to make up the correct length — the shallower the angle, the better. Don't let it bend back on itself because fields from parallel wires tend to cancel. If you can get from a half to three-quarters of an antenna suspended straight between supports, it will perform almost as well as if the whole thing were in a straight line.

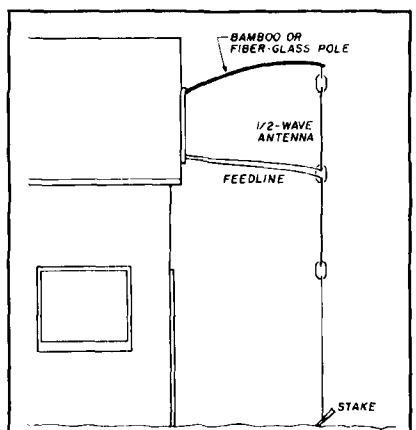


fig. 2. A dipole hung from a fishing-pole out of a high window is a quick solution for a 1-meter requirement. You can use light-gauge wire and small insulators here, and RG-58A-U is fine for short feedline runs.

The radiation pattern (that "doughnut" mentioned earlier) will not be ideal from antennas that slope or zigzag around the lot between supports; but they'll work, and will snag a surprising number of contacts for you.

It's great if you can increase the height of the lower support, but you *can* put up a relatively inexpensive, easy-to-install antenna between convenient supports. You'll enjoy lots of QSOs while waiting for that magic day when you can afford a pair of great towers on a zillion-acre lot with no neighbors within miles.

a vertical dipole

Figure 2 shows another way to use a half-wave antenna. This one is especially useful on 10 meters, a band that will be really hopping now that Novices have voice and digital privileges on it. The idea is simplicity itself: just stick the longest bamboo (or glass fiber) fishing pole you can find out of your highest window, and hang an antenna from the end of it. Try it and join the fun without investing in a lot of hardware!

Keep the antenna as high as possible for two reasons: it will perform better, and will keep the "hot" end from the reach of curious bystanders. (Those rf burns are nasty, and heal very slowly!) Again, the feed can be either coaxial cable or twin lead.

The antenna will still work if your house has metal siding, but will show some VSWR on the line and radiate most of its power away from the house. You can adjust for the VSWR problem with a Transmatch, or change the length of the elements very slightly to get rid of it. Start with the antenna a few inches longer than called for by the formula, and remove an inch at a time from each end until the VSWR gets down to a level that's right for your equipment.

a quarter-wave antenna

Because of its size, a quarter-wave antenna has many possible mounting schemes. That same chain-link fence that helps anchor the mast for a "sloper" can serve as a ground system for a quarter-wave vertical (see **fig. 3**).

Adapt some mobile-mounting hardware to clamp the base to the posts or top railing, run some coax across the lawn, and plug it in. Height helps, but not as much as you might think, especially on a wide-open 10-meter band. A vertical for 15 meters is still within reason for this type of mount, but you'll need a rugged fence and plenty of strong tubing to make it work for 40 meters. A shortened 40-meter quarter-wave antenna does work, however. It can be made with a loading coil at the base and a capacitive "top hat" that achieves resonance with physical lengths as short as one-eighth wave or less. Be aware; this "shorty" is a very fussy, high-Q device that requires retuning if you move your frequency very far. The feedpoint impedance is often very low, and needs a good matching circuit and large wires to carry the higher current without loss.

the multiband antenna

Many Amateurs, beginners and old-timers alike, rack up a respectable number of QSOs each year using vertical antennas built to work on several bands. Most of the available "all-band" antennas now include the new frequencies gained at the recent WARC conferences. This type of antenna is constructed of aluminum tubing with trap circuits placed at various spots along its length. It is fed with coaxial cable, and once mounted and adjusted for proper operation, needs no further attention. Just switch your transmitter to whatever band you want; the antenna is ready. Many excellent antennas are advertised in magazines, and you can often get a bargain on a used one when someone upgrades his system.

The vertical multiband antenna also requires a ground to work against, and the fence comes to mind once more. Alternatives are a metal balcony or porch railing, galvanized pipe driven into the ground, or a roof peak with several wire "radials" fanning out from the mounting hardware.

Don't ignore the metal rain gutters around your house. They are often

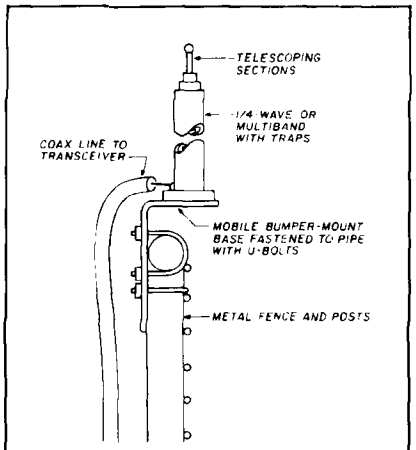


fig. 3. A metal fence support structure or porch/balcony railing can serve as a ground system and support for vertical 1/4-wave antennas or a multi-band vertical. A modified mobile bumper mount can be clamped to the posts or railing.

enemies because they reflect or absorb energy from a nearby antenna, but they can be friends as well. Use them as additional "ground plane" for a roof-mounted antenna. If not attached to metal siding, they can even be loaded up to serve as an antenna. (The radiation pattern will be strange, and you'll have rf on the bathroom fixtures, but it will work!)

"Verticals" needn't be exactly vertical. I read about a vacationer who carried a collapsible multiband vertical in his luggage. He simply assembled the sections and clamped the base to the hotel balcony railing, tilting the antenna at whatever angle was needed to clear the balcony above. He made many exciting contacts in faraway places with this bit of ingenuity.

So don't mourn for the lack of an ideal location. If you can stick up a piece of wire or tubing, and make it the right length (or use traps or tuners to make your transmitter think it's the right length), it will work and you'll have a ball.

mounting tips

It is relatively easy to put up simple antennas, and most of them work well. But there are a few things that will turn a useful dipole into a bird roost. Don't let the ends of the antenna wander off into the bushes where branches and leaves can make contact with the wire. These ends are the most sensitive parts of an antenna, and a water-laden limb or bunches of leaves will have the effect of putting a big resistor across the antenna — they will detune it and absorb power. If you must use a tree to support an antenna, clear all branches away from the wire.

Most trees do a lot of swaying in the wind, and it is best to plan for this at the beginning. Put some springs between the insulators and supports at both ends. I like to put at least two springs at the end that attaches to the tree, and one at the fixed-support end. Use springs that compress under tension. (A screen-door spring that stretches will eventually fatigue to the point where the antenna sags too much.) Don't try to pull the antenna so tight that it resembles a guitar string. Give it enough slack that temperature variations and wind sway won't break anything.

what length?

Here are a few formulas to help you decide if you have enough room between supports to put up an antenna, or to measure the tubing or wire needed.

For a half wave in free space:

$$length\ (feet) = \frac{492}{f(MHz)} \quad (1)$$

for an antenna made of wire (most common):

$$length\ (feet) = \frac{468}{f(MHz)} \quad (2)$$

for a quarter-wave wire antenna:

$$length\ (feet) = \frac{234}{f(MHz)} \quad (3)$$

When an antenna such as a vertical quarter wave is made of tubing, the diameter-to-wavelength ratio is large enough that the length must be shortened from those derived from the wire antenna formula. Your best bet is to make the antenna out of telescoping sections and vary the length for best performance.

ham radio

JUNE 1988 / $2.50

ham radio magazine

hr

focus
on
communications
technology







FIELD DAY

ham radio magazine

JUNE 1988

volume 21, number 6

T. H. Tenney, Jr., W1NLB
publisher
and editor-in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
production editor

Peggy Tenney, KA1QDG
copy editor

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W7ERS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Rally Dennis, KA1JWF
director of advertising sales

Henry S. Gallup
advertising sales manager

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Phil Alix, KA1IDP
traffic manager

Farm Color
cover

Bill Santelmann, N1AU
Marty Durham, NB1H
cover photos

ham radio magazine is published monthly by Communications Technology, Inc., Greenville, New Hampshire 03048-0498. Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail):
one year, $31.00; two years, $55.90; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank.

international subscription agents: page 73

Microfilm copies are available from University Microfilms, International, Ann Arbor, Michigan 48106. Order publication number 3076.

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107.

Copyright 1988 by Communications Technology, Inc. Title registered at U.S. Patent Office.

Second-class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices.
ISSN 0148-5989

**Send change of address to *ham radio*
Greenville, New Hampshire 03048-0498**

contents

8 design program for the grounded-grid 3-500Z
W.J. Byron, W7DHD

19 designing a station for the microwave bands: part 2
Glenn Elmore, N6GN

39 VHF/UHF world: propagation update — part 2
Joe Reisert, W1JR

54 the Quad antenna: part 2 circular and octagonal loops
R.P. Haviland, W4MB

68 ham radio techniques: a nifty bi-square beam for 10 or 12 meters
Bill Orr, W6SAI

72 practically speaking: "ferriting" out the problem
Joe Carr, K4IPV

78 Yagi vs. Quad, part 2
David Donnelly, K2SS

95 Elmer's notebook: "Q" signals
Tom McMullen, W1SL

on the cover: John Webster, K1FWE (bottom left), and Doug Grant, K1DG (bottom right), operating during the 1986 K1AR Field Day effort. Both are SFRCC members. Top photo: Marty Durham, NB1H, "fixing things" on N1AU's tower.

98 advertisers index
6 comments
88 DX forecaster
90 flea market
92 ham mart
84 new products
98 reader service
4 reflections



REFLECTIONS

Novice enhancement and the future of Amateur Radio

Since going into effect last spring, Novice enhancement hasn't caused any great upsurge in the Amateur ranks. Whether it should be considered a modest success or a complete failure seems to depend on who's talking.

If the criterion is merely the decrease in Novice licensees compared with a year ago, Novice enhancement has failed. To me that's a very shallow, superficial interpretation resulting from a cursory reading of the numbers and a misplaced belief that enhancement addressed a basic problem of Amateur Radio rather than an ancillary one.

Discounting the big Novice jump in April and May of 1987, when a lot of newcomers rushed in to take the Novice exam before it was expanded to cover new privileges, the Novice population hasn't shown a significant change in the past year. There are, perhaps, many reasons for that. How many of last year's new licensees didn't even pause at Novice but moved up immediately? How many of them had been putting off becoming Amateurs and were stimulated to take the Novice exam before it got tougher? These and many other questions should be answered before the results of Novice enhancement can be properly assessed.

Some critics now say the problem with Novice enhancement is that it didn't go far enough, and what's really needed is to do away with the CW "boogie man". Though I agree that the CW requirement has long intimidated — and will continue to intimidate — a vocal minority of prospective Amateurs, I also firmly believe that any attack on the CW issue, no matter what its outcome, will have no more effect on the long or short term Amateur growth problem than Novice enhancement did!

Whatever your feelings, neither Novice enhancement nor a no-code license addresses the basic problem. The problem isn't our product, but its marketing. Amateur Radio is a great product, but if our potential customers don't know the product exists, where to find it, or appreciate its many benefits, they aren't going to buy!

Intelligent marketing is based on market analysis. Manufacturers who don't understand this are doomed to slow growth and/or stagnation at best, and the bankruptcy court at worst. Analyses of recent licensees by the FCC and the VEs who are actually bringing the newcomers on board agree that the average new Amateur is an older, well-established adult. Our marketing effort has been aimed at youngsters, so it seems likely we've been targeting the wrong market. The ARRL seems to feel this way, and is now experimenting with a pilot program that encourages older residents of the Tampa/St. Petersburg, Florida area to become hams.

Before investing any great amount of money and effort in new sales pitches or product revisions, I suggest we put some of that money into a professional market study. This study should be directed primarily at those Amateurs who've joined us in the past 10 to 12 years and (when possible) those who've dropped out. It should include questions on how and why respondents became Amateurs, what they felt had helped, or what had hindered their developing Amateur Radio interest. When the study's results are analyzed, the most cost-effective marketing strategy may become clear.

The ARRL and the Amateur Radio Industry Group have the capabilities for such a study. The two worked together well on the *Archie's Ham Radio Adventure* comic book project, and might be willing to work together on this one. In the meantime, however, I feel that any further tinkering with the product isn't going to solve the basic problems, only complicate them.

Joe Schroeder, W9JUV

This editorial is one person's opinion about Novice enhancement and does not necessarily represent the views of *ham radio*. Ed.



comments

tips for construction projects

Dear HR:

Boy, am I glad that I started building projects *before* reading Paul A. Johnson's article in your March 1988 issue. I'm sure Mr. Johnson's piece would have scared me away. Here are some suggestions for any of your readers who might be interested in project construction:

1. Don't start with anything rf. Receivers, transmitters, tuners, linears are all difficult and require a lot of adjustment once they're assembled. As I recently discovered, even a simple dummy load isn't simple. Don't start with a high-voltage or high-current power supply either. Anything over about 50 volts or 5 amps requires extra care and construction technique. Start with something like a 12 volt 3 amps power supply to run your HT in the house. How about a digital clock? Use a National Semiconductor MA1023C module *and matching transformer* from Digi-Key and it'll be easy. Get a Curtis chip and make a keyer. These suggested projects may not sound very exciting technically, but you'll find that project construction is often more mechanical than electrical.

2. You don't have to build most projects in metal boxes. For non-rf projects, plastic is fine. It's inexpensive, easy to work, and doesn't have to be painted. Jameco, Digi-Key, and your local Radio Shack all offer a selection of plastic enclosures. Stick with plastic and you won't need a drill press; an electric hand drill is fine. You won't need expensive and dangerous hacksaws, sabre saws, circular saws, or fly cutters either. Holes larger than your drill can make or odd-shaped openings can be cut quickly and easily with a reamer or some cheap files. Filing out openings in metal is an arduous task, but in plastic even cheap files cut quickly. Here's a tip: to drill a nice hole in plastic, start with your smallest bit and work up to the final size using every bit between them in your index. Hot-melt glue guns work on plastic. A cheap pop riveter is another handy tool. If you do need metal, look for a prefab cabinet that will fit your project. Prefabs may seem expensive, but they're a lot easier and you won't need a lot of tools and equipment. Bud, LMB, and others offer an excellent assortment of cabinets ready to house most projects.

3. *Plan! Document!* Much of the work for my projects is done on paper. Start with a good schematic. If you're using any integrated circuits, mark the pin numbers on your schematic. Draw pin diagrams of other parts like transistors next to the part on the schematic. Assign part numbers. Sketch how the project will be assembled, the layout of parts on circuit boards, and the chassis wiring. Then make a from-to wiring list. With all of this planning, your project will be a snap to build and will work the first time. If it doesn't, all the documentation will help you find the problem fast. By the way, keep all of this paper so that if your *project ever* breaks, you ever want to modify it, or you or a friend ever want to build another, it'll be easy. As you correct bugs or add modifications, document the changes.

4. Take your time. Measure twice, cut once. Make test fits as you move along. Check each electrical connection with an ohmmeter. Try to make every solder joint perfect. Use cable ties or lacing tape to form cable bundles. If you have extensive chassis wiring, use wire marker labels. Use heat-shrink tubing and cable clamps as necessary. In short, try to make each project a show piece inside and out.

While Mr. Johnson's work certainly looks very nice, project construction does not have to be as difficult or as complicated as he makes it sound. You don't have to be a machinist, and you really don't need a lot of expensive tools either. By avoiding complicated projects (especially rf ones) at first, using plastic boxes whenever possible, planning carefully, and working slowly, anyone can enjoy building perfect construction projects. I know I sure do!

Chuck Gollnick, KA7QEN
Ames, Iowa 50010-1363

no contest

Dear HR:

In his article in the November 1987 issue, Bill Orr, W6SAI, says he can attest to the fact that allocation of even a small segment of the 30-meter band to SSB operation would be of great benefit to Amateur Radio. Instead of a bland statement, would he be a bit more explicit?

Surely he must be aware that another well-known author sparked a similar controversy in the columns of the RSGB's *RadComm* magazine, and the consensus of opinion was against any change in the IARU's recommendations. Could there be a conspiracy of authors on this subject?

I have used the 30-meter band almost since it's inception, and the greatest problem is finding a space to work without causing QRM to priority users. Like many others, I have worked over 100 countries; the DX is there and occupancy will surely improve as we advance into the new cycle.

Would the SSB fraternity be as mindful of our non-priority status as the CWers have been? I doubt it, and it would not be long before we lost the band altogether.

I wholeheartedly agree with his 18 MHz sentiments and it would be a great shot in the arm to have the W/Ks on the band, but please *no contests*. As my friend SM3CIQ/U1F says; rather RTTY QRM than contests.

Edward D. Ross, 5B4OG/A9XCE
Larnaca, Cyprus

design program
for the grounded-grid 3-500Z

This program gives "no-compromise" answers

There are probably as many amplifiers in existence that use the 3-500Z as there are with any other power amplifier tube. The 3-500Z is an excellent tube with a well-deserved reputation for high power-handling capabilities and reasonable cost. There are no doubt hams with one or two spare 3-500Zs in their shacks who are thinking of building their own amplifiers. But of course, it's one thing to copy the design of another amplifier and a different matter to design one's own from scratch.

Circuit variations for amplifier designs are available from other sources[1] and I will not discuss them here. This article covers only one mode of operation for the 3-500Z — grounded-grid class AB_2 operation — probably the most prevalent use of the tube. I will discuss virtually all possible combinations of drive power, load resistance, drive impedance, plate voltage, and bias requirements for grounded-grid, linear operation. I have included a program which allows you to accommodate any set of normal operating conditions that can be realized on the constant-current curves. **Figure 1** is the program listing.

This program's answers are probably a bit more precise than ones obtained with the "Tube Performance Computor".[2] You might assume that linear divisions exist between constant-current curves on the tube charts; they don't. This is not a serious problem, as variations from one tube to another will usually be greater than those differences. It is important to remember that using the hand-calulated methods consumes much paper, time, and nervous energy. My program lets you change any of the input parameters and see the differences for *each* proposed operating condition in a few seconds, as compared with fifteen minutes or a half-hour required for hand-calculated answers — and it doesn't make mistakes!

The program has only 170 lines to enter; it runs completely within a few seconds after you enter the last input. (The answers appear in about 3 seconds on the Tandy-2000, and in 8 to 10 seconds on an early IBM PC.) When this program is compiled, answers appear in under a second. The program is very densely packed with numbers and equations — I know of no other way to define every current and voltage (including fractional values) that can be found on the tube chart, and still use fewer than 7 kilobytes of computer RAM. The labor of typing the program pays for itself many times over as it saves hours of effort during a design routine.

how to use the program

Figure 2 is a reproduction of the "EIMAC 3-500Z Typical Constant Current Characteristics" curves for grounded-grid, class AB_2 operation. The operational area of the program (crosshatching) is superimposed on the curves. Stay inside the "box"; it includes every permissible or useful operating point. You decide on the placement of the operating (or load) line. It is drawn between two points, labeled "i_p", and "Q". The first defines the maximum peak instantaneous plate current as well as the minimum plate voltage. The second defines the quiescent (no drive) value of the plate current, and occurs at exactly the plate-supply voltage. The chart also tells you the quiescent plate dissipation. This is not printed in the program output, but can be calculated by multiplying the resting plate current by the plate supply voltage. The program requests: "Enter Plate Supply Voltage, E_{bb}",

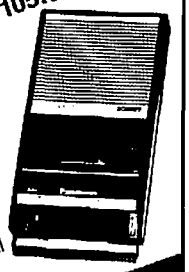
By W.J. Byron, W7DHD, 240 Canyon Drive, P.O. Box 2789, Sedona, Arizona 86336

fig. 1. The 3-500Z Design Program Listing.

```
10 ' SAVED AS 500WRK8
168 PRINT"                    3-500Z Grounded-Grid Characteristics"
170 PRINT"                  Subroutines Copyrighted 1987, W J Byron"
172 PRINT"                              All rights reserved"
173 PRINT:PRINT
190 INPUT"Enter Plate Supply Voltage, Ebb";E3
191 IF E3>4500 THEN PRINT"       EXCESSIVE PLATE VOLTAGE!":GOTO 190
200 INPUT"Enter Peak Plate Current, Ip";I1
205 IF I1>1.6 THEN PRINT"        EXCESSIVE PEAK CURRENT!":GOTO 200
210 INPUT"Enter Minimum Plate Voltage, Emin";E4
220 IF E4 < 250 THEN PRINT"      HIGH GRID CURRENT AREA!": GOTO 210
221 IF I1>=1.6 AND E4<=1499 OR E4>3000 THEN PRINT"OUT OF BOUNDS!":GOTO 210
222 IF I1>1.4 AND E4<=1499 OR E4>3000 OR I1>1.4 AND E4<1500  THEN PRINT"OUT OF B
OUNDS!":GOTO 210
230 INPUT"Enter Cathode Bias Voltage (Zener)";E2
240 IF E2<0 THEN PRINT"       Negative Cathode Bias Not Permitted!": GOTO 230
290 CLS
300 PRINT"                              3-500Z"
310 PRINT"                  RADIO FREQUENCY LINEAR AMPLIFIER"
320 PRINT"                     Cathode Driven, Class AB2"
330 PRINT"_____________________________________________________________________"
331 PRINT"Ebb =";E3;"     Ip =";I1;"      Emin =";E4;"      Bias (Zener) =";E2
340 PRINT"_____________________________________________________________________"
350 IF E4=>2000 AND I1>.4 AND I1=<1! THEN GOTO 6000
360 IF E4=>2000 AND I1=<.4 THEN GOTO 5000
370 IF E4=>1500 AND E4=<3000 AND I1>1! AND I1=<1.6 THEN GOTO 7000
380 IF E4=>250 AND E4<2000 AND I1>.4 AND I1=<1 THEN GOTO 3000
390 IF E4=>250 AND I1>1! THEN GOTO 4000
400 IF E4=>250 AND E4<2000 AND I1<.4 THEN GOTO 2000
410 '
500 GOSUB 1000
510 I6 = (I(1)/2+I(2)+I(3)+I(4)+I(5)+I(6)+I(7))/12:
520 I7 = (I(1)+1.93*I(2)+1.73*I(3)+1.41*I(4)+I(5)+.52*I(6))/12:
540 GOSUB 11000
600 '
620 N=1
630 FOR AD = 90 TO 180 STEP 15
640 AR = AD*3.14159/180
650 E5 = (-E1+E2)*SIN(AR)
660 E5 = -E5+E2
670 GOSUB 8000
671 IF E4 >=250 AND E4<1500 THEN GOSUB 9000
672 IF E4>=1500 THEN GOSUB 10000
692 N=N+1
693 NEXT AD
694 E1 = -E1
695 I5 = (I4(1)/2+I4(2)+I4(3)+I4(4)+I4(5)+I4(6)+I4(7))/12
697 I8 = (I4(1)+1.93*I4(2)+1.73*I4(3)+1.41*I4(4)+I4(5)+.52*I4(6))/12
698 I9=I7+I8:E7=E3-E4
710 PD = E1*I9/2:PFT=I7*E1/2:P1=(E1-E2)*I8/2:Z1=E1/I9:P1=E3*I6:PO=E7*I7/2:
720 PP=P1+PFT-PO:ZI=E1/I9:ZO=E7/I7:
722 PRINT"Plate Supply Voltage                =                    ";E3;"Volts"
724 PRINT"Cathode Bias (Zener)                =                    ";INT(10*E2)/1
0;"Volts"
726 PRINT"Zero Signal Plate Current           =                    ";INT(1000*I2)
;"mA dc"
728 PRINT"Single-Tone Plate Current           =                    ";INT(1000*I6)
;"mA dc"
730 PRINT"Single-Tone Grid Current            =                    ";INT(1000*I5)
;"mA dc"
732 PRINT"Grid Power Dissipation              =                    ";INT(P1+.5);"
Watts"
734 PRINT"Peak RF Cathode Voltage             =                    ";INT(10*E1)/1
0;"Volts"
736 PRINT"Feed-through Power                  =                    ";INT(PFT+.5);
"Watts"
738 PRINT"Grid Drive Power                    =                    ";INT(PD);"Wat
ts"
739 PRINT"Total Cathode Drive Power           =                    ";INT(PD+PFT+P
1);"Watts"
740 PRINT"Cathode Drive Impedance             =                    ";INT(10*ZI)/1
0;"Ohms"
742 PRINT"Power Input                         =                    ";INT(PI);"Wat
ts"
744 PRINT"PEP Power Output                    =                    ";INT(PO);"Wat
ts"
746 PRINT"Plate Dissipation                   =                    ";INT(PP);"Wat
ts"
748 PRINT"Plate Load Impedance                =                    ";INT(ZO);"Ohm
s"
750 PRINT"_____________________________________________________________________"
760 INPUT"Do you want to change an input - Y or N";A$
762 IF A$ = "Y" OR A$ = "y" THEN 764 ELSE END
764 INPUT"Which: Ebb (1), Ip (2), Emin (3) or Bias (4) - Enter Number";B
766 ON B GOTO 768, 770, 772, 774
768 INPUT"New Plate Supply Voltage";E3:GOTO 290
770 INPUT"New Peak Current, Ip";I1:GOTO 290
772 INPUT"New Min. Plate Voltage";E4:GOTO 290
774 INPUT"New Bias Voltage";E2:GOTO 290
1000 '
1041 N=1
1050 FOR AD = 90 TO 180 STEP 15
```




NEW
SUPER LONG PLAY TAPE RECORDERS
12 Hour Model — $105.00*
USES D-120 TAPE



Modified Panasonic Slimline, high quality, AC-DC Recorders provide 6 continuous hours of quality recording & playback on each side of cassette for a total of 12 hours. Built-in features include • Voice level control • Digital counter, etc. TDK DC 120 Cassette Furnished.

PHONE RECORDING ADAPTER



Records calls automatically. All Solid state connects to your telephone jack and tape recorder. Starts recording when phone is lifted. Stops when you hang up. $24.50*

FCC APPROVED

VOX VOICE ACTIVATED CONTROL SWITCH



Solid state. Self contained. Adjustable sensitivity. Voices or other sounds automatically activate and control recorder. Uses either recorder or remote mike. $24.95*

*Add for ship & hdlg. Phone Adapter & Vox $1.50 ea. Recorders $4.00 ea. Cal. Res. add tax. Mail order, VISA, M/C, COD's OK. Money Back Guarantee. Qty. disc. avail., Dealer Inquiries Invited, Free data. ©
AMC SALES INC. Depth 9335 Lubec St., Box 928, Downey, CA 90241 Phone (213) 869-8519

179

COMPUTERIZE YOUR SHACK

YAESU 747, 757GX, 757GXII, 767, 9600.
KENWOOD TS 440, TS 940,
ICOM R71A, R7000, 735, 751A.
DRIVERS FOR RADIOS ARE MODULAR.
NEW MODELS BEING ADDED EVERY DAY.

COMPLETE PROGRAM ENVIRONMENT
MENU DRIVEN AND DESIGNED FOR EASE OF USE.
SCAN FUNCTION ADDED TO RADIOS THAT DO NOT SUPPORT IT.

MENUS FOR THE FOLLOWING:
- AMATEUR HF—AMATEUR VHF—AMATEUR UHF
- AM BROADCAST—FM BROADCAST—TELEVISION BROADCAST
- SHORT WAVE BROADCAST
- AVIATION HF(SSB)—AVIATION VHF—AVIATION UHF
- HIGH SEAS MARINE—VHF MARINE
- MISCELLANEOUS HF, VHF, UHF
- MOST POPULAR FREQUENCIES ALREADY STORED
- ADDITIONAL LIBRARIES AVAILABLE
- COMPLETE LOGGING FACILITY
- ALL FREQUENCY FILES MAY BE ADDED TO, EDITED OR DELETED

AVAILABLE FOR IBM PC, XT, AT, 80386 256K RAM
1 SERIAL PORT AND 1 FLOPPY MINIMUM

PROGRAM WITH INITIAL LIBRARIES 99.95
RS—232 TO TTL INTERFACE ONLY
NEEDED IF DON'T HAVE MANUFACTURERS INTERFACE ALLOWS 4 RADIOS 99.95
SPECTRUM ANALYZER MODULE (CALL FOR PRICE)

DATACOM, INT.
8081 W. 21ST. LANE
HIALEAH, FL 33016
AREA CODE (305) 822—5792

180

```
1070 AR = AD*3.14159/180
1080 E5 = (-E1*E2)*SIN(AR)
1090 E5 = -E5+E2
1091 GOSUB 8000
1092 IF E6 <>2000 THEN GOSUB 13000 ELSE GOSUB 12000
1100 N=N+1
1110 NEXT AD
1130 RETURN
2000 '
2030 A = 1.17040 + 8.70277E-03*E4 - 8.7317E-07*E4^2
2040 B = -372.2766 + .3693*E4 - 1.9797E-04*E4^2
2050 C = 1192.038 -2.3118*E4 + .0013494*E4^3
2060 D = -1466.98 + 3.5197*E4 - .002135*E4^2
2070 E1 = (A +B*I1 +C*I1^2 +D*I1^3)
2090 GOTO 410
3000 '
3030 A = 34.095 + 1.526857E-02*E4 - 8.4952E-06*E4 2
3040 B = -339.196 + .026530*E4 + 1.6960E-05*E4^2
3050 C = 381.55 - .106071*E4 - 4.7619E-07*E4^2
3060 D = -183.7 + .088096*E4 - 1.26987E-05*E4^2
3070 E1 = (A +B*I1 +C*I1^2 +D*I1^3) + 1.5
3090 GOTO 410
4000 '
4030 A = 15.3333 - .204*E4 + 6.6667E-05*E4^2
4040 B = -171.805 + .5971*E4 - .0001903*E4^2
4050 C = 69.3 - .53895*E4 + .0001759*E4^2
4060 D = -17.3612 + .16667*E4 - 5.5556E-05*E4^2
4070 E1 = (A+B*I1 +C*I1^2 +D*I1^3)
4100 GOTO 410
5000 '
5030 A = 2.5971 + 6.17953E-03*E4 + 6.9333E-08*E4^2
5040 B = -197.3858 - .012861*E4 - 2.7028E-06*E4^2
5050 C = 297.348 + .0315373*E4 + 2.440133E-05*E4^2
5060 D = -231.3046 - .0085463*E4 - 4.3113E-05*E4^2
5080 E1 = A +B*I1 +C*I1^2 +D*I1^3
5100 GOTO 410
6000 '
6030 A = 59.3 - .015733*E4 + 1.467E-06*E4^2
6040 B = -400.519 + .09939*E4 - 6.04467E-06*E4^2
6050 C = 430.4 - .142*E4 + .0000084*E4^2
6060 D = -179.1328 + .0650273*E4 - 3.85547E-06*E4^2
6080 E1 = A +B*I1 +C*I1^2 +D*I1^3
6100 GOTO 410
7000 '
7030 A = -1102 + 1.0133*E4 - 1.9867E-04*E4^2
7040 B = 1855.833 - 1.89027*E4 + 3.7722E-04*E4^2
7050 C = -1106.25 + 1.16075*E4 - .0002375*E4^2
7060 D = 197.9143 - .23264*E4 + 4.86107E-05*E4^2
7070 E1 = (A +B*I1 +C*I1^2 +D*I1^3)
7090 GOTO 410
8000 '
8060 M = (E3-E4)/(E2-E1)
8070 B = E4-M*E1
8080 E6 = M*E5 + B
8100 RETURN
9000 '
9030 A = .028344 - 1.40085E-04*E6 + 6.60444E-08*E6^2
9040 B = -2.855E-05 - 5.972E-06*E6 + 2.52651E-09*E6^2
9050 C = 4.4072E-05 - 6.0547E-08*E6 + 2.1886E-11*E6^2
9060 I4(N) = A +B*E5 + C*E5^2
9061 IF E5>=-24 THEN I4(N)=(-E5/24)*.05
9062 IF E5=>0 THEN I4(N)=0
9080 RETURN
10000 '
10030 A = -.11518 + 1.121096E-04*E6 -2.515184E-08*E6^2
10040 B = -.010834 + 7.15948E-06*E6 - 1.42553E-09*E6^2
10050 C = -5.206347E-05 + 5.38044E-08*E6 - 1.1G1174E-11*E6^2
10060 I4(N) = .94*(A +B*E5 + C*E5^2)
10061 IF E5>=-24 THEN I4(N)=(-E5/24)*.05
10062 IF E5=>0 THEN I4(N)=0
10080 RETURN
11000 '
11030 A = .0342397 + 1.505585E-06*E3 + 6.804935E-09*E3^2
11040 B = -.0051687 - 3.0065E-07*E3 - 2.15583E-10*E3^2
11050 C = 1.8582E-04 - 1.95465E-08*E3 + 3.351883E-12*E3^2
11060 I2 = A + B*E2 + C*E2^2
11070 IF I2<0 THEN I2=0
11080 IF E2 > (E3+417.5)/150 THEN I2 = 0
11100 RETURN
12000 '
12030 A = .014419 + 2.0981E-05*E6 - 1.11584E-08*E6^2 + 7.9275E-12*E6^3
12040 B = -.0052947 + 2.2872E-06*E6 - 1.2934E-09*E6^2 - 1.4654E-13*E6^3
12050 C = 7.4159E-05 - 4.2928E-08*E6 + 1.17198E-10*E6^2 - 4.8095E-14*E6^3
12060 D = 4.0815E-07 - 1.1512E-09*E6 + 1.5312E-12*E6^2 - 5.1342E-16*E6^3
12070 I(N) = (A +B*E5 +C*E5^2 +D*E5^3)*.985
12090 RETURN
13000 '
13030 A = -.090832 + 1.0172E-04*E6 - 1.1786E-08*E6^2
13040 B = -9.8964D1E-03 + 2.5720E-06*E6 - 5.7867E-10*E6^2
13050 C = 8.6724E-05 + 2.5902E-08*E6 - 1.5486E-12*E6^2
13080 D = -1.8581E-07 + 1.30725E-10*E6 + 1.184E-14*E6^2
13070 I(N) = A +B*E5 +C*E5^2 +D*E5^3
13071 IF I(N)<0 THEN I(N)=0
13090 RETURN
```

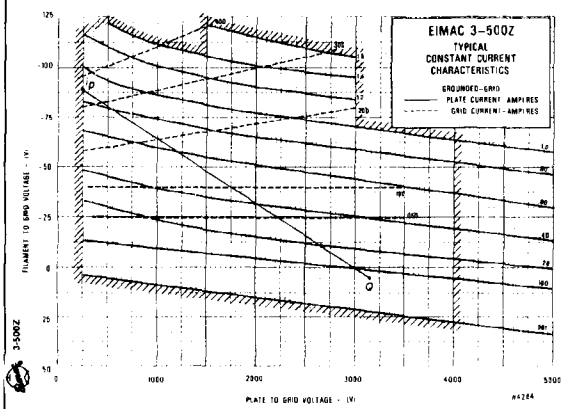


fig. 2. The 3-500Z Constant Current Characteristics Curves with the program boundaries marked. Stay inside the cross-hatched area. The load line is for the solution in *fig. 4*.

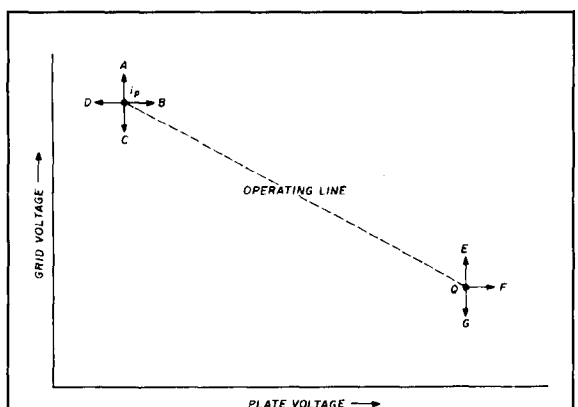


fig. 3. Diagram of the possible movement of the Operating Line. For use with *table 1*.

"Enter Peak Plate Current, i_p", "Enter Minimum Plate Voltage, E_{min}", and "Enter Cathode Bias Voltage (Zener)".

These four inputs define both ends of the operating line (which you may already have drawn on the curves), and are sufficient to determine all operating parameters. It isn't actually necessary to draw the line, but it may help to visualize it; one appears in the figure to demonstrate the method.

The main program starts immediately after the last input and calculates a total of fifteen lines of data. Two are input repetitions (Plate Supply Voltage and the Zener Bias); the rest are results of internal calculation by the program. These are the numbers you want. The inputs are repeated in the line just below the heading for the program output as a record of what has been entered. Use them as starting points for any changes

Table 1. The effects of moving points i_p and Q in the designated directions.

Movement in direction	Results of movement
A:	Higher grid current
	Higher plate current
	Higher input and output
	Higher plate dissipation
	Lower drive impedance
B:	Reduced efficiency
	Lower input and output
	Reduced grid current
	Increased plate current
C:	Reduced grid current
	Reduced Plate current
	Reduced input and output
D:	Higher distortion
	(peak flattening)
	Increased grid current
E:	Lower distortion
	Higher quiescent dissipation
F:	Increased input and output
	Increased efficiency
	Increased plate dissipation
	(Do not exceed mfgr's max
	Plate Voltage)
G:	Lower quiescent plate current
	Lower quiescent plate dissipation
	Increased distortion
	(non-linear "crossover")

you want to make. After the listing there is a question: "Do you wish to change an input—Y or N?" If you enter "Y", the program in turn will ask you, "Which one?" in a menu, and you can change any one of the four inputs until the outputs are to your liking. Any other entry, including "N", will abort the program and you will have to "RUN" again. You can then use the "immediate mode" of BASIC to calculate, for instance, the quiescent plate dissipation (which as a rule of thumb should be somewhere between 30 and 40 percent of the maximum plate dissipation -- 500 watts for this tube).

There are some constraints imposed on the initial inputs (see lines 190 through 240). These conditions do not exist at the "Do you wish to change an input?" prompt. Because you are typing the program youself, you decide whether or not to include them (use your own good judgement). To do so, just duplicate the conditions stated in the lines identified above. The constraints result partly from the maximum values permitted by the manufacturer and partly from my work to limit both maximum grid dissipation and amplifier distortion. The program isn't valid outside these limits; the manufacturer's allowable values are the principal reasons for the lower limit of 250 volts for the minimum plate voltage.

Certain changes will occur when the positions of

```
Ebb = 3150      Ip = .87      Emin = 250      Bias (Zener) = 5.2

Plate Supply Voltage                =        3150 Volts
Cathode Bias (Zener)                =        5.2 Volts
Zero Signal Plate Current           =        67 mA dc
Single-Tone Plate Current           =        278 mA dc
Single-Tone Grid Current            =        90 mA dc
Grid Power Dissipation              =        6 Watts
Peak RF Cathode Voltage             =        87.8 Volts
Feed-through Power                  =        19 Watts
Grid Drive Power                    =        25 Watts
Total Cathode Drive Power           =        50 Watts
Cathode Drive Impedance             =        152.2 Ohms
Power Input                         =        878 Watts
PEP Power Output                    =        617 Watts
Plate Dissipation                   =        279 Watts
Plate Load Impedance                =        6806 Ohms

Do you want to change an input - Y or N?
```

fig. 4. Program output for the design for two parallel 3-500Zs with 3150 plate supply volts, and 100 watts total drive.

Table 2. Comparison of calculated and manufacturer's data.

Parameter	Program Calc.	Mfgr. Data	Program Calc.	Mfgr. Data
Plate Supply Voltage	1500	1500	3500	3500
Cathode Bias	0	0	+15	+15
Quiescent Plate Current	51	65	25	53
Single-Tone Plate Current	403	400	396	400
Single-Tone Grid Current	142	130	129	108
Grid Drive Power	51	49	49	46
Cathode Impedance	134	94	137	115
Power Input	605	600	1386	1400
PEP Output	330	330	991	890
Plate Load Impedance	1602	1600	5001	5000

points "i_p" and "Q" are moved. **Figure 3** is a schematic showing what to expect when shifting the points. Use it in conjunction with **table 1**. It is essential that you be familiar with these principles — that's the only way you will accomplish your final design.

how well does the program work?

The proof is in the performance. A sample of the program output appears as **fig. 4**, which is also the demonstration of a design using two parallel 3-500Zs. It looks just like the manufacturer's list of typical operating data.

Table 2 compares the program-calculated data with those published by EIMAC under the heading "Typical Operating Data". The results of trying to match two sets (at 1500 volts and 3500 volts) are compared in the table. The manufacturer's data came from the latest technical data sheets for the 3-500Z (the revision effective April 1, 1986).[3] I have culled all except the directly comparable data from the table; they are remarkably close. **Figures 5** and **6** are the program outputs for the 1500- and 3500-volt cases.

parallel operation

All the tables reflect data for one tube. If you choose a two-tube parallel operation, all currents and power levels must be doubled. All impedances (such as the cathode drive and plate load impedances) must be halved. Voltages remain unchanged.

A hypothetical design demonstration follows:

Suppose you have a power transformer that will deliver 3500 volts dc at no load. A typical power supply voltage will sag about 10 percent under load, so enter 3150 for E_{bb}. Now suppose that you have 100 watts of drive (PEP) from the exciter, and you also want to have the most power available from the amplifier.

The program was run with initial inputs of 3150 volts, 1.0 A (chosen as a starting point), 250 volts, and 5.2 volts. The Zener was chosen as 5.2 volts because it is about the same bias voltage as that used in the Heath SB-220. It proved to be a good choice. By reducing i_p incrementally via the menu, the calculated drive power was reduced to 50 watts exactly (for one tube). It occurred when the max plate current (i_p) reached 0.87 A (see **fig. 4**). By "doubling and halving," the resulting numbers for two tubes in parallel are:

Plate Supply Voltage = 3150 volts
Cathode Bias = 5.2 volts
Zero Signal Plate Current = 134 mA dc
Single-Tone Plate Current = 556 mA dc
Single-Tone Grid Current = 180 mA dc
Feed-Through Power = 38 watts
Total Cathode Drive = 100 watts

```
Ebb = 1500        Ip = 1.31        Emin = 470        Bias (Zener) = 0

Plate Supply Voltage                =          1500 Volts
Cathode Bias (Zener)                =          0 Volts
Zero Signal Plate Current           =          51 mA dc
Single-Tone Plate Current           =          403 mA dc
Single-Tone Grid Current            =          142 mA dc
Grid Power Dissipation              =          14 Watts
Peak RF Cathode Voltage             =          117.9 Volts
Feed-through Power                  =          38 Watts
Grid Drive Power                    =          51 Watts
Total Cathode Drive Power           =          103 Watts
Cathode Drive Impedance             =          134.4 Ohms
Power Input                         =          605 Watts
PEP Power Output                    =          330 Watts
Plate Dissipation                   =          312 Watts
Plate Load Impedance                =          1602 Ohms

Do you want to change an input - Y or N?
```

fig. 5. Program output for duplicating the manufacturer's data for 1500 plate supply volts.

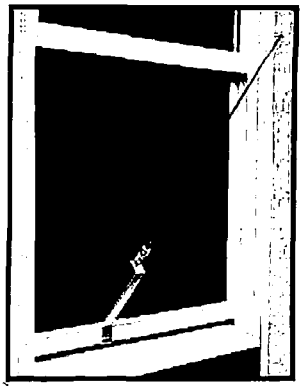
```
Ebb = 3500        Ip = 1.25        Emin = 350        Bias (Zener) = 15

Plate Supply Voltage                =          3500 Volts
Cathode Bias (Zener)                =          15 Volts
Zero Signal Plate Current           =          25 mA dc
Single-Tone Plate Current           =          396 mA dc
Single-Tone Grid Current            =          129 mA dc
Grid Power Dissipation              =          11 Watts
Peak RF Cathode Voltage             =          116.6 Volts
Feed-through Power                  =          37 Watts
Grid Drive Power                    =          49 Watts
Total Cathode Drive Power           =          97 Watts
Cathode Drive Impedance             =          137.1 Ohms
Power Input                         =          1386 Watts
PEP Power Output                    =          991 Watts
Plate Dissipation                   =          430 Watts
Plate Load Impedance                =          5001 Ohms

Do you want to change an input - Y or N?
```

fig. 6. Program output for duplicating the manufacturer's data for 3500 plate supply volts.

PORTABLE ANTENNA



MODEL AP-10

Designed for
APARTMENTS
MOTELS
VACATIONS

$64.95

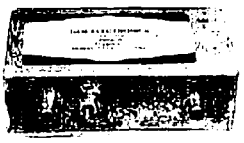
Add $3.00
Shipping and Handling

Quick Simple Installation. Operates on 2, 6, 10, 15, 20, 30 and 40 meters. All coils supplied. Only 22-1/2 inches long. Weighs less than 2 lbs. Supplied with 10 ft. RG 58 coax and counter poise. Whip extends to 57 inches. Handles up to 300 watts.
VSWR—1.1:1 when tuned
Write for more details and other B&W products

ALL OUR PRODUCTS MADE IN USA
B&W BARKER & WILLIAMSON
Quality Communication Products Since 1932
At your Distributors. Write or Call.
10 Canal Street, Bristol PA 19007
(215) 788-5581

HIGH PERFORMANCE PRESELECTOR-PREAMP

The solution to most interference, intermod, and desense problems in **AMATEUR** and **COMMERCIAL** systems.



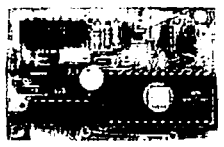
- 40 to 1000 Mhz - tuned to your frequency
- 5 large helical resonators
- Low noise - High overload resistance
- 8 dB gain - ultimate rejection > 80 dB
- 10 to 15 volts DC operation
- Size - 1.6 x 2.6 x 4.75" exc. connectors
- **FANTASTIC REJECTION!**

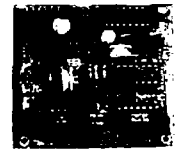
Typical rejection:
±600 Khz@144 Mhz: -28dB
±1.6 Mhz@220 Mhz: -40dB
±5 Mhz@450 Mhz: -50dB

Price - CALL bipolar w/RCA jacks
Connector options: BCN $5, UHF $6, N $10
SUPER HOT! GaAs Fet option $20

AUTOMATIC IDENTIFIERS

ID-1





ID-2

- For transceivers and repeaters - **AMATEUR** and **COMMERCIAL**
- Automatic operation - adjustable speed and amplitude
- Small size - easy installation - 7 to 15 volts DC
- 8 selectable, reprogrammable messages - each up to 2 min. long
- Wired, tested, and programmed with your message(s)

Model ID-1 - $54.95 Model ID-2 w/2 to 10 minute timer - $79.95

We offer a complete line of transmitter and receiver strips and synthesizers for amateur and commercial use.
Request our free catalog. *Allow $2 for UPS shipping - Mastercard and VISA welcome*

GLB ELECTRONICS, INC.
Dept H, 151 Commerce Pkwy., Buffalo, NY 14224
716-675-6740 9 to 4

Cathode Drive Impedance = 76 ohms
Power Input = 1756 watts
PEP Power Output = 1234 watts
Plate Load impedance = 3403 ohms

The actual power output would be (1234 + 38) or 1272 watts because of the feed-through power. Total plate dissipation would be 559 watts. The design can proceed from here.

Always keep the manufacturer's maximum ratings in mind. Two appropriate values to monitor are the plate dissipation and the maximum plate voltage. Another more important one is grid dissipation, also calculated by the program. Normally you will never exceed all the maximum ratings at once — but stay alert to assure that it doesn't happen. This program should be accompanied by the manufacturer's tube data sheets.

comments

In **table 2** there are two lines which show some discrepancies; neither of these is very important. They involve plate quiescent current and cathode drive impedance. These numbers agree with those calculated by hand from the EIMAC Bulletin No. 5 "Tube Performance Computor". Even so, the **table 2** "worst-case" discrepancy (cathode drive impedance for the 1500-volt case) would result in a VSWR of only 1.4. Everything else came out much better than I expected.

My program is complicated and takes lots of time. But remember that when the work is done, the resulting program will simulate data for an operational circuit. It should be emphasized that "real" tubes may produce numbers which differ by as much as ± 10 percent in the main part of the characteristics curves. Though I have made many design calculations with the aid of this program, I certainly have not challenged every possible entry. I would be interested in your results. Let know if there are any "glitches" in the program, and send me your suggestions for improvements.

I plan to put several design programs on disk. I have done this same routine for the 3CX1200A7; the routines for the 8877 are half-finished. I will tackle each tube type in succession until most of the common tubes are covered. In the meantime, I hope you have good results with this 3-500Z design program.

acknowledgment

Thanks to Frank Chess, K3BN, who helped with the programming. It was his idea to echo the inputs at the heading of the output routine.

references

1. W.J. Byron, W7DHD, "Design an Amplifier Around the 3CX1200A7," *ham radio*, December 1987, page 33
2. Bulletin Number 5, "Tube Performance Computor," Varian/EIMAC, 301 Industrial Way, San Carlos, California 94070
3. Available from Varian/EIMAC, 1678 Pioneer Road, Salt Lake City, Utah 84104

ham radio

174

designing a station for the microwave bands: part 2

A complete 10-GHz Amateur SSB/CW station

Part 1 discussed why the microwave Amateur bands may be better than lower frequencies for many applications, though in the past Amateurs have viewed them as line-of-sight realms. It described some of the inherent advantages microwaves have for point-to-point communication, even over modern higher power hf, VHF, or UHF stations. These advantages make them very attractive for high volume, high data rate communications like those required for Amateur networking.

A local oscillator frequency scheme using common pc boards was presented. It can be used to get a station on all of the Amateur microwave bands with a minimum of redundant construction. This scheme uses conventional lower frequency components, readily available microwave oscillators, and only a small amount of additional microwave construction to produce a high quality narrowband station. Part 1 and the rest of this series demonstrate this approach by describing construction of a complete 10-GHz Amateur SSB/CW station — the station that holds one end of the current North American 10-GHz DX record of 414 miles.

spectral purity

The cornerstone of this station is a spectrally pure and stable 1010-MHz oscillator. Spectral purity, sometimes overlooked more than it should be even on the hf bands, is of particular importance when operating on microwave frequencies. This is because the "contamination" produced by angular (phase or frequency) modulation of a low-frequency reference signal is multiplied right along with the signal itself when a harmonic is used in a microwave system. The fact that drift and frequency errors are multiplied is well known to anyone who tries to "net" a pair of fm transceivers on 1200 or even 440 MHz. However, these frequency domain "imperfections" are members of a whole class of impurities given the name "phase noise". Even a quartz oscillator in a modern hf transceiver exhibits this to some degree. In a well-designed oscillator the "cleanliness" of a signal is related to its operating frequency. On the Amateur hf bands these noise characteristics may be so small relative to normal signal-to-noise ratios that they are unobservable, except to-noise ratios that they are unobservable, except perhaps as an increase in background noise level down the band from a local "big gun". Some of the early synthesized ham band transceivers exhibited this as noise "humps" a few kHz either side of the carrier frequency on both transmit and receive. Commercial Amateur equipment has improved to the point where fundamental overload or other factors usually come into play before the phase noise of the local oscillators is observed. However, as higher frequencies are required and higher harmonic multiples of reference oscillators are used, these unwanted components are multiplied. The relative amplitude of these unwanted signals follows a 20 log N rule, where N is the harmonic number. This means that on the tenth harmonic of a signal, the phase noise sidebands can be expected to increase by 20 log 10 or 20 dB. The 100th harmonic will be 40 dB worse than the fundamental. Consequently, a "clean" signal at 10 MHz, one with say −90 dBC (dB relative to the carrier) noise sidebands or fm spurious signals, might be 60 dB worse at 10 GHz, or −30 dBC. On an S9 signal such noise might be barely audible; however, if the fundamental oscillator was only −60 dBC the resulting microwave signal might be unusable for communications. Because the 1010-MHz oscillator and its harmonics provide a local oscillator signal for a narrowband station, spectral purity must be maintained. Although a PLL can serve to "clean up" a poorer oscillator at frequencies close in to the carrier, no improvement is made

By Glenn Elmore, N6GN, 3528 Deerpark Drive, Santa Rosa, California 95404

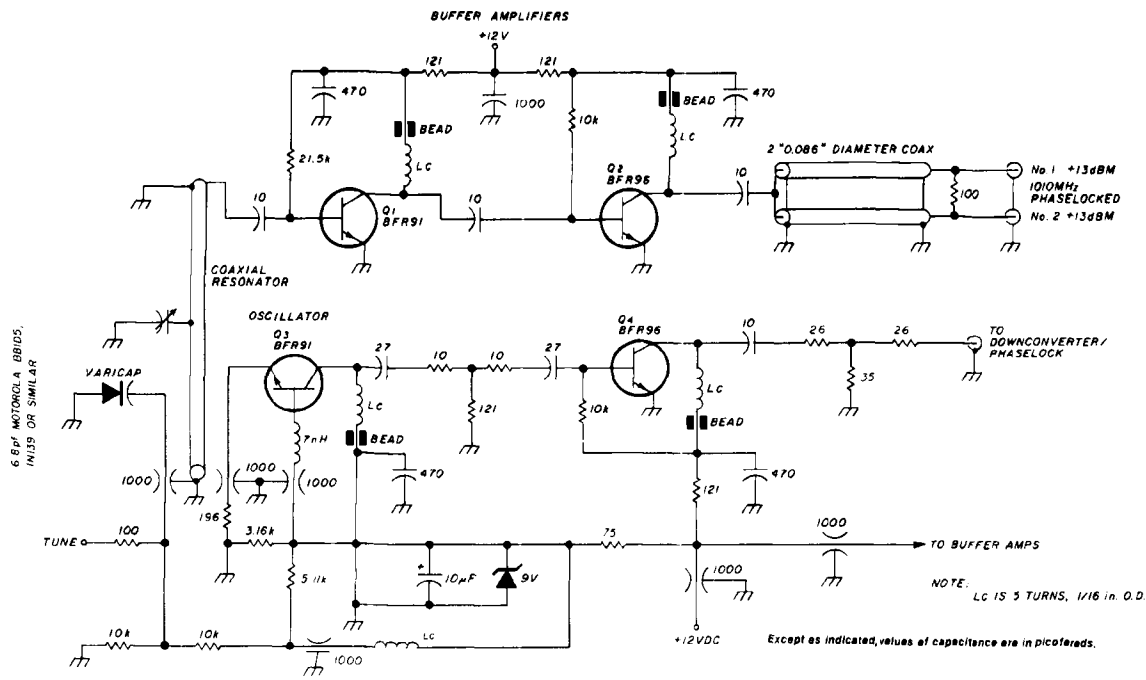


fig. 1. The 1010-MHz oscillator circuit uses a coaxial resonator tuned with a voltage variable capacitor and coupling inductor. The oscillator transistor drives the phaselocking circuitry through a buffer amplifier. Two outputs for signal mixing or microwave PLLs are taken from the other end of the half-wave resonator after two stages of amplification.

beyond the PLL bandwidth. For this reason the best available oscillator should be used.

1-GHz reference oscillator

This oscillator can be used as the LO for a 1296-MHz signal mixer directly, as well as for the microwave harmonic downconverter reference at microwave frequencies. The active device is an inexpensive bipolar transistor. A coaxial resonator is made from pc board and brass tubing. Three separate buffered outputs are provided for phase locking, downconverter reference, and 1296-MHz signal mixer LO. The oscillator is tuned with the same UHF TV tuner diode used in the 100-MHz reference along with a short length of wire coupled to the resonator at the low-impedance end. This provides approximately ± 3-MHz tuning range around a 1010-MHz center frequency.

Oscillator tuning is somewhat novel; it works in much the same way as "loop modulation" of early radio days. Free running high-power oscillators were used with a carbon microphone connected across a single-turn loop located in the vicinity of a frequency determining inductor. As the operator spoke into the microphone the resistive load across the loop varied, which in turn modulated the loop current. Because this was an induced current, it tended to produce an opposing flux which effectively varied the net tank inductance and frequency modulated the oscillator. The technique works, but be careful not to couple too closely or extract so much energy from the tank that you burn up the microphone — not to mention the operator!

The method used here doesn't extract much power from the tank, as the load the varicap presents to the loop is mostly reactive. Any such dissipation is undesirable as it acts to lower the operating *Q* of the resonator. The varicap value and coupling wire inductance are chosen to be below self-resonance for any tuning voltage. This is done to limit the maximum current and control energy loss in the tuning circuit resistances. If the tuning circuit tunes too close to resonance, oscillation may stop. With nominal loop dimensions and the indicated varicap, the 1010-MHz oscillator tunes with a nearly straight frequency/voltage tuning curve. The 5-MHz tuning range is ample to maintain lock once the other loops and coarse tuning are adjusted to center the output frequency.

Two versions of this oscillator have been built. The first uses a quarter-wave line allowing physically smaller construction, but requiring a dielectric support for the high-impedance end of the line to obtain the lowest "microphonics". The second approach uses a

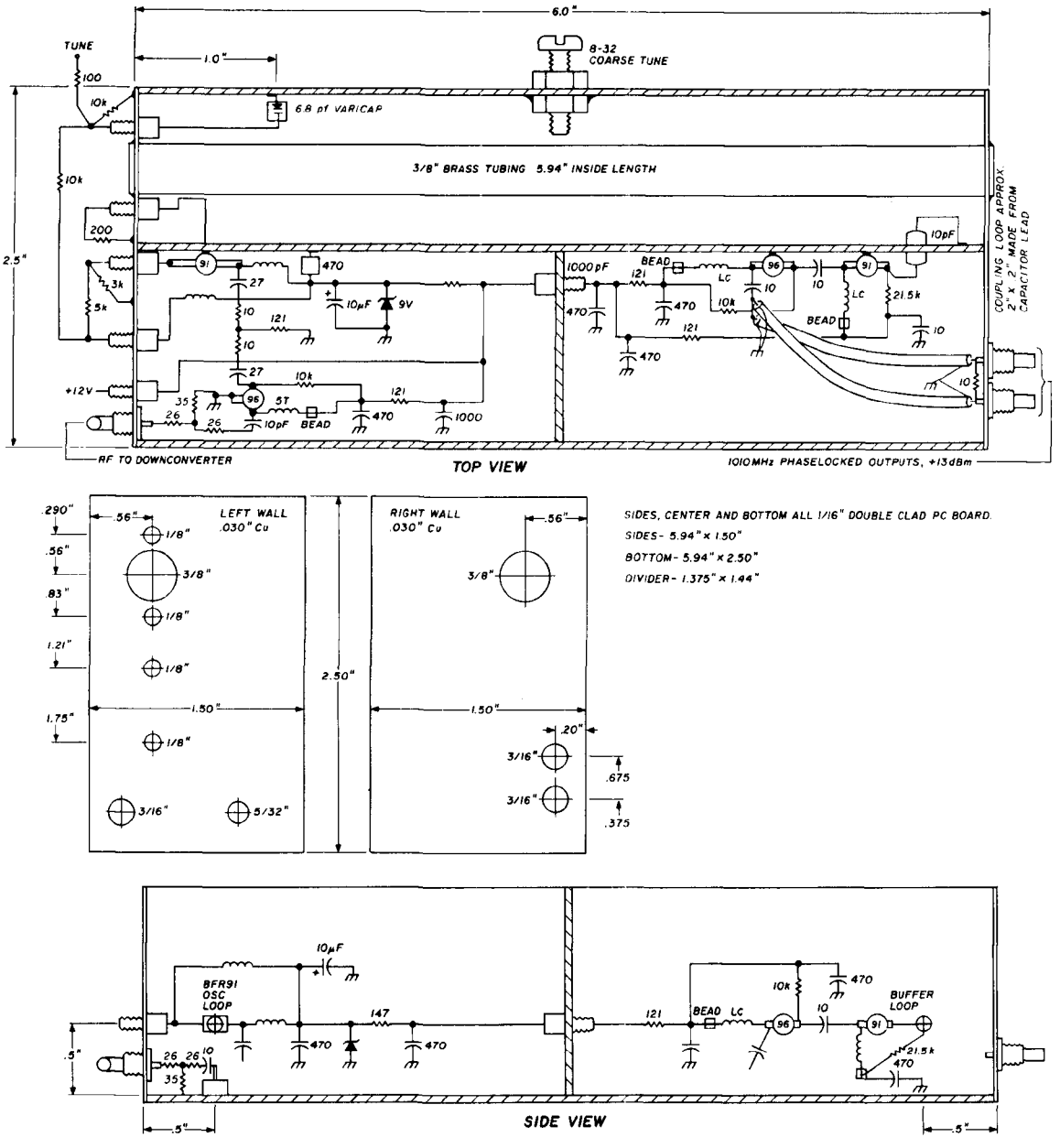


fig. 2. The 1010-MHz oscillator is built from pc board and copper flashing. The assembly is divided into three compartments — one for the resonator and one each for the oscillator and signal amplifier circuits. Minimum lead length is used when components are soldered directly to the circuit board material.

half-wave line and, although longer, is simpler to construct. The quarter-wave version allows tuning versatility by "telescoping" the inner conductor with a length of the next smaller size brass tubing sliding through the center of the fixed tubing. It tuned it continuously from 800 to more than 1200 Mhz.

The half-wave version has another advantage. When you place the oscillator transistor with its isolation amplifier on one end of the resonator and signal amplifiers on the other end, the resonator serves to isolate spurious signals which might be present in the downconverter/phase lock circuitry. This "autofiltering" makes it easier to achieve −80 dBC spectral purity at 1 GHz. Similar performance can be obtained with the quarter-wave version, but more stages of isolation and careful shielding are required.



fig. 3. 1-GHz oscillator.

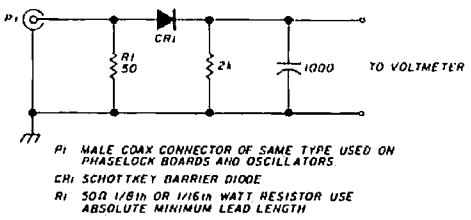


fig. 4. A simple diode detector and voltmeter can measure signal power up through the VHF range. The circuit is useful for relative power measurement well past 1 GHz.

The BFR91 oscillator transistor is optimized to have maximum negative resistance at 1 GHz with the insertion of approximately 7 nH of inductance in its base lead. This inductor is just the 3/8 inch of lead length between the transistor package and the feedthrough capacitor ground on the end wall. The emitter is coupled into the resonator with a loop, also bypassed in a feedthrough capacitor on the same wall. Base and emitter biasing resistors are connected on the outside. The 1-GHz oscillator schematic is shown in **fig. 1**. **Figure 2** shows the mechanical dimensions and positioning for the resonator, feedthrough capacitors, and coupling loops. A photo of the completed oscillator is shown in **fig. 3**.

construction

The oscillator could be built entirely of pc board, but I chose to make the end walls from copper flashing. This makes it easier to solder the brass tubing after the resonator box has been assembled. The sides, center, ends, and partition should all be punched or drilled before soldering. Holes for the oscillator emitter loop and buffer amplifier input loop are in the center wall. Amplifier transistor emitters and all bypass capacitors can be soldered directly to the board material with virtually no excess lead length. The oscillator emitter lead can protrude right through the center wall hole and be soldered to its coupling loop. An 8-32 brass nut should be soldered to the inside wall of the resonator so that a tuning screw can be inserted later. If possible use 1/8th or 1/16th watt resistors. The physically smaller packages should have less associated inductance. Choose feedthrough capacitors small enough to fit snugly against the brass tubing on the oscillator end. These must be soldered in place since their nuts would otherwise interfere with the brass tubing protruding from the end wall.

adjustment

Begin check-out without tuning screws and apply 12 volts. The oscillator emitter (measured at the outside of its feedthrough capacitor) should sit at about 3.5 volts, and the amplifier transistors should have 6 to 10 volts on their collectors. Collector currents of about 15 mA for the BFR91 and 40 mA for the BFR96 amplifiers are fine. All three outputs should have a load connected; a 50-ohm resistor may be tacked across an unused output as a temporary load. If a power meter or other calibrated detector is not available, an inexpensive power detector may be made (**fig. 4**). An approximate calibration curve useful through the VHF range is shown in **fig. 5**. At 1 GHz the curve may not accurately predict the detected power because of

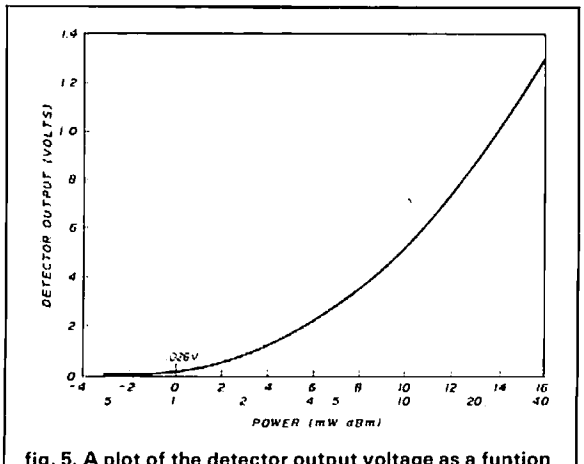


fig. 5. A plot of the detector output voltage as a funtion of input power shows a useful range from about 0 to +16 dBm (1 to 40 milliwatts).

differing construction techniques and component characterisics, but the detector should still be useful for determining relative output powers and adjusting the 1010-MHz circuits. I built the detector right on the cable end of the same type of SMB coax connector I used throughout. You can use it to verify ECL outputs as well as oscillator performance.

A 1-GHz frequency counter or a spectrum analyzer

is extremely useful for tune-up. If such test equipment is not available, build the 1-GHz harmonic downconverter described in the next section. Use it to convert the 1-GHz signal down to the hf range of a general coverage receiver or low frequency counter. If you use a receiver, couple the downconverter lightly or use an attenuator to avoid overload. Overloading can cause confusion because of images and other spurious responses.

With an applied fixed tuning voltage of 6 volts, insert the tuning screw and set the frequency to approximately 1010 MHz. Adjust the emitter loop slightly to assure oscillation while varying the tuning voltage over the 2-to-10 volt varicap tuning range. Reduce coupling by decreasing the area of the loop and positioning it further from the brass tubing. Use the minimum coupling to maintain output so you can avoid unnecessarily loading the resonator and degrading phase noise. This coupling is somewhat dependent on resonator loading by both the tuning circuit and buffer amplifier input loops. Adjust the buffer amplifier loop (made from the coupling capacitor lead) for minimum coupling consistent with maximum power out of the power splitter. Adjust the emitter loop to maintain output over the whole tuning range. Some iteration between these two adjustments may be necessary to arrive at the best settings. If you find that the oscillator dies at the high end of the tuning range, or just above 10 volts, you may need to lower the tuning circuit resonant frequency. Do this by lengthening the tuning inductor slightly. The values shown in the drawing should provide a good starting place and should work without modification. Extreme emitter loop overcoupling can cause "squegging", the output switching rapidly between two frequencies. This is not a problem if the above adjustment procedure is followed. Reduce coupling if you observe spurious sidebands on the unlocked oscillator or find low-frequency oscillations on the bias feedthrough capacitors.

The output amplifier on the signal side is followed by a power splitter made from two 2-inch lengths of semi-rigid coax. This is a simple way to provide two outputs. If only one 1010-MHz source is required, it may be omitted and the single BFR91 buffer amplifier used to provide +10 dBm for a signal mixer. The two-stage amplifier with a BFR96 in the output and the power divider can easily provide two +13 dBm (20 milliwatt) sources.

Once the loops are positioned for proper power output, all that remains is to readjust the tuning screw so the oscillator "free runs" right at the desired frequency. If you adhere to the dimensions for the half-wave version, the oscillator should run at about 1025 MHz with no tuning screw and only the 4.5 volts from the resistive divider on the tuning input. It should tune down mechanically to 1000 MHz without a significant change in output power. When you obtain the proper frequency, secure the tuning screw locking nut. Verify that approximately + and − 2 MHz tuning is produced with 10 volts and 2 volts on the tuning input, respectively.

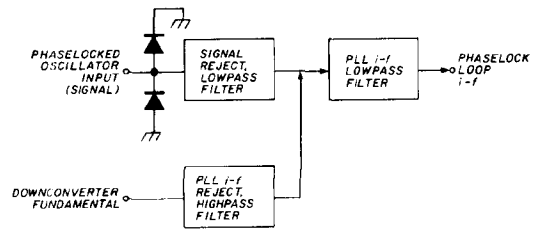


fig. 6. This harmonic downconverter produces an i-f output which is the difference between N multiplied by the downconverter fundamental and the phaselocked oscillator input, where N is an even number. With inexpensive diodes and Amateur construction techniques, i-f output power of −30 dBm is readily available.

PLL harmonic downconverters

The downconverters themselves are similar, although implementation at 10 GHz is somewhat different from that at 1 GHz. Anti-parallel diodes are used with a diplexer arrangement to couple signals in and out. The downconverter block diagram is shown in **fig. 6**.

The anti-parallel diode pair is effectively an *even* harmonic mixer. Its simplicity and built-in protection from overload and static damage make it attractive for this application. Depending on harmonic number and phase-locked oscillator frequency, −30 to −40 dB conversion efficiencies are obtainable even with "ham shack" construction — i.e., discrete components or microstrip circuits cut out of Teflon™ epoxy pc board material with a small hobby knife. The high-pass filter couples the reference fundamental into the diodes; the low-pass filter couples the i-f out. The oscillator can be connected directly to the diode pair through a small capacitor.

At 1 GHz, packaged diodes and discrete capacitors and inductors can be used. Lead length should be kept to a minimum, but otherwise the circuit is extremely simple to build. The diodes generate considerable energy at odd harmonics of 100 MHz. However, the isolation of the 1010-MHz oscillator resonator, not to mention the buffer amplifiers, keeps this energy from showing up in the signal output. These sidebands are for the most part amplitude, not frequency modulated, and don't get "amplified" when higher harmonics of the 1010-MHz signal are used as a reference signal in the 10-GHz downconverter. The PLL i-f signal

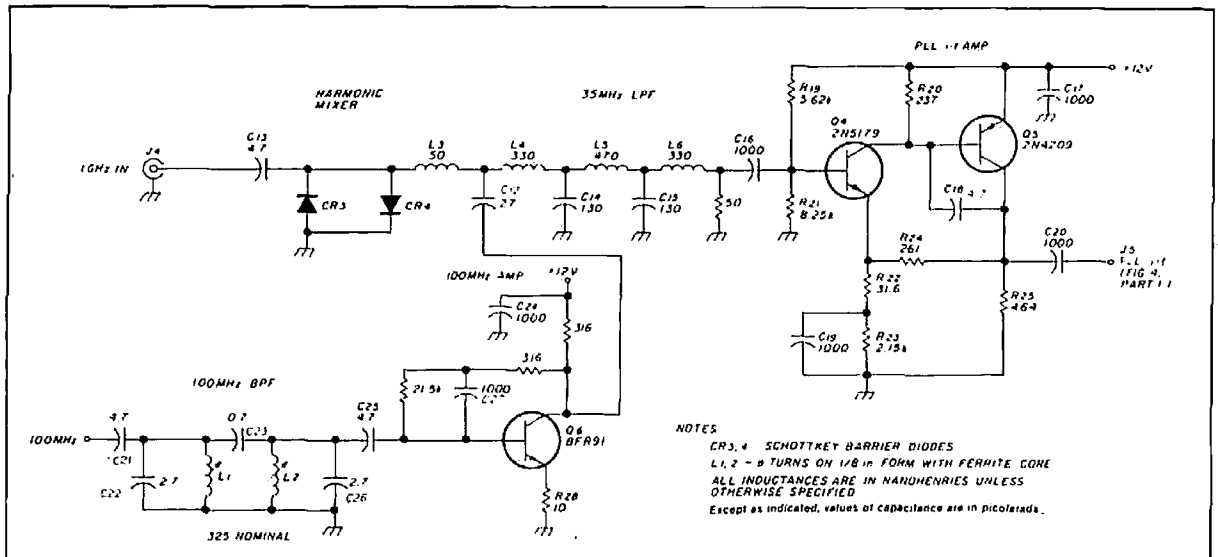


fig. 7. The 1-GHz harmonic downconverter and i-f amplifier circuit produce approximately −10 dBm i-f output when driven with 100-MHz ECL levels and the 1010-MHz oscillator. Leads should be kept short and good VHF practice followed, otherwise no special precautions need to be taken.

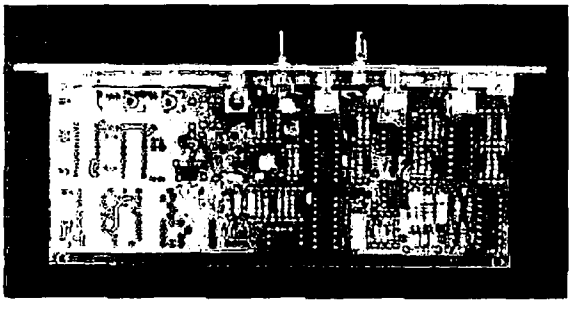


fig. 8. Completed 1-GHz downconverter and common PLL board.

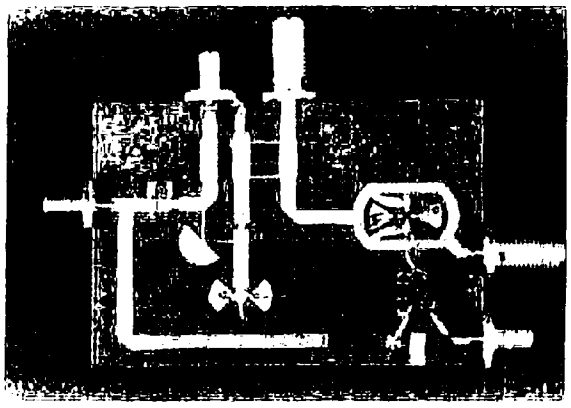
from the downconverter is approximately 30 dB below the reference or locked oscillator levels. This conversion loss is made up for in the bipolar amplifier and the two ECL line receivers on the phase-lock circuit. With 10 to 13 dBm reference drive, i-f output doesn't change dramatcally for 0 to 10 dBm oscillator input. Around −30 dBm PLL i-f power is typical for both converters — plenty to drive the last ECL line receiver before the phase comparator well into saturation. The i-f output may actually drop if the oscillator input level is increased too far. The 1-GHz harmonic downconverter schematic diagram is shown in fig. 7. Figure 8 is a photo of the completed 1-GHz downconverter and common PLL board.

The 100-MHz reference signal is bandpass filtered and amplified from the 0-dBm ECL levels. The filtering makes sure that any low level, low-frequency digital signals which might be present on the 100-MHz ECL output don't "ride" straight through to the PLL i-f amplifiers. Diode drive of 10 to 20 milliwatts is adequate.

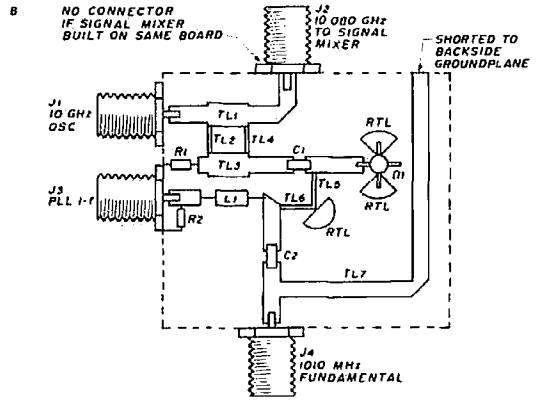
The 10-GHz downconverter is functionally the same as the 1-GHz version. Here, however, a pair (or half a quad) of diodes in a small package is used to avoid parasitic inductance and capacitance associated with the larger discrete diodes. Many of the filler elements are made using microstrip techniques instead of lumped components. Chip capacitors are used to minimize parasitic inductance.

Because most of the 10-GHz oscillator power is needed for converting the VHF signal to and from 10 GHz, a hybrid coupler is used to extract only enough to make the PLL downconverter operate. This hybrid has one of its input ports terminated with a discrete resistor. This termination needn't be very good at 10 GHz, as the object of the coupler is simply to extract a sample of the energy (10 dB or so down) and its directivity isn't particularly important. Use as physically small a resistor as possible with 0 lead length. All of the high-impedance lines may be made from some small diameter wire and soldered across the wider traces. Number 38 wire should be fine for this.

The signal mixer is shown with the 10-GHz downconverter and can be built on the same board at the same time. This makes it possible to get on the band as soon as the 10-GHz oscillator is locked and a VHF i-f is available. The 10-GHz harmonic downconverter is shown in figs. 9A and 9B. Figure 10 shows a 2:1

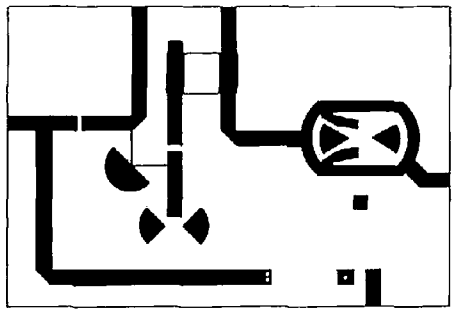


A



D1 HP HSCH-6812 DIODE QUAD OR METELLICS MSS3D-142-E45
TL1, TL3 100" WIDE x 0.23" LONG
TL2, TL4, TL5, TL6 #36-#40 BARE WIRE x 0.20" LONG
L1 0.1μH CHOKE
C1 47 pF CHIP CAPACITOR
C2 27 pF CHIP CAPACITOR
RTL 0.145" RADIUS QUARTER OR HALF CIRCLE
TL7 AND ALL OTHER LINES 0.083" WIDE
R1, R2 1/16 WATT OR SMALLER 50Ω
J1-J4 MA-COM OR SIMILAR FLANGED SMA CONNECTOR
BOARD MATERIAL 1/32" THICK DOUBLE CLAD DUROID 1.5" x 1.7"
CONNECTOR FLANGES SOLDERED TO BACKSIDE GROUNDPLANE
R1, R2 SOLDERED TO FLANGE OF J3

fig. 9. The 10-Ghz and 1010-MHz downconverters are functionally identical. At 10 GHz, however, microstrip components replace discrete components. A hole is provided in the 1/32 inch Teflon board material under diode ring, D1, to allow shorting the diode leads to the backside ground. Radial transmission lines on these same leads help assure a low-impedance ground connection.



NOTE: BOARD MATERIAL IS 1/32" DOUBLE CLAD TEFLON "FIBERGLASS. DUROID" MAY BE USED.

fig. 10. The downconverter/signal mixer assembly is the only microwave circuit that needs to be constructed. The traces may be made using a small hobby knife by the "cut and peel" technique. Tolerances are not extremely critical although a microscope can be a great aid. More detail of the downconverter and signal mixer portions is given in figs. 9 and 19, respectively.

C

layout of the combined 10-GHz downconverter/signal mixer; **fig. 11** shows a schematic of this board.

locking to 1010 MHz

The 1010-MHz common PLL circuit is nearly identical to that of the 100-MHz reference oscillator — only the loop filter values are different. For this loop, the phase comparator VCO input comes from the filtered and amplified output of the 1-GHz harmonic downconverter. A 35-MHz low-pass filter follows the downconverter; the PLL i-f is first amplified by a two-stage controlled-gain amplifier. I used this configuration instead of another ECL line receiver for two reasons: it allowed variation of the stage gain by changing a single resistor value, and the bipolar amplifier has lower bandwidth than the ECL line receiver. The rest of the PLL circuitry is identical to the 100-MHz phase lock except for the loop filter component values. The bandwidth of this loop is set to approximately 50 kHz.

Once the 1010-MHz oscillator is built and adjusted, you are ready to lock it up. Use one of the common PLL boards with the loop filter component values in part 1, **table 2**. Set the jumper wires on the phase comparator input for the "+" configuration. If the PLL board is working properly (remember that you can test it ahead of time by using it to lock up the 100-MHz oscillator), the loop should close and "pull in" the 1010-MHz oscillator exactly on frequency. This lock can occur if the 100-MHz loop is locked or free running, and the output frequency should be exactly 10.1 times the 100-MHz crystal oscillator frequency. Make sure you use the 10-MHz reference to lock at 1010 MHz and the 20-MHz reference if you are trying to lock to 1020 MHz.

Troubleshoot any problems by checking the PLL board and the 1010-MHz oscillator independently of each other. As long as the oscillator tunes over the correct range and the PLL board is working, there

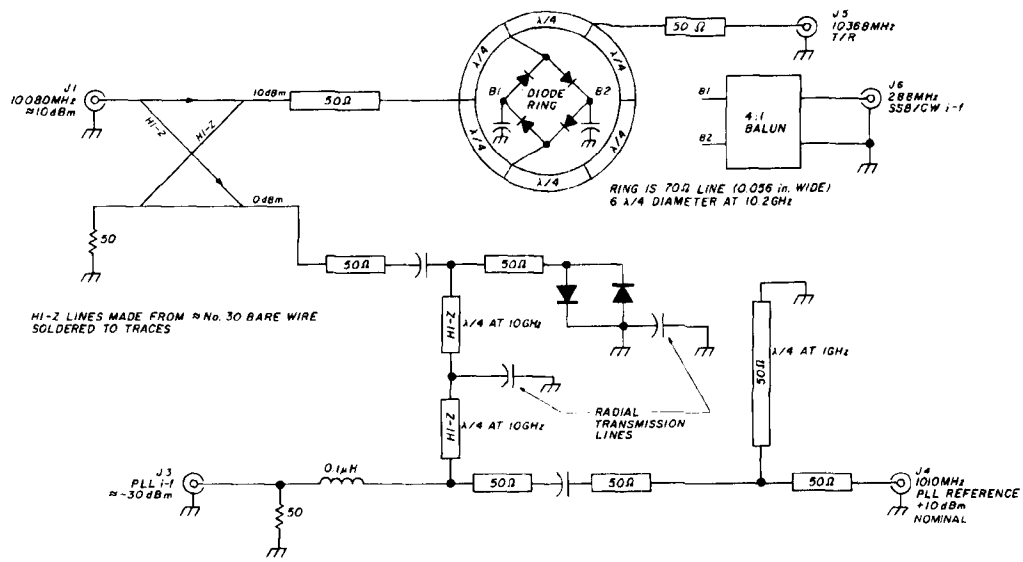


fig. 11. The microwave board mainly uses distributed elements. Impedance of the microstrip transmission lines is controlled by width variation. The high-impedance lines can be made from bare No. 30 wire soldered right to the traces; this is easier than trying to cut or etch 0.005-inch wide traces.

should be no difficulty in achieving and maintaining lock. Once this is done, you have an LO for use in a 1296/2304 station or as a reference oscillator for locking your 10-GHz oscillator.

10-GHz oscillator selection and locking

The 10-GHz oscillator is locked in the same manner as the 1010-MHz reference. The tuning circuit may depend on the type of oscillator available. Generally, only enough tuning range to overcome drift and instability is used. If too much tuning range is provided, the microwave oscillator might get on the "wrong side" of the downconverter reference frequency harmonic, giving an i-f with the wrong tuning sense. If this happens, the PLL amplifier tries to tune the oscillator in the wrong direction to acquire phase lock and the loop will remain saturated and unlocked. For a 20-MHz PLL i-f, 30 MHz of total electronic tuning range should be adequate, and this combined with about a 10-volt swing out of the loop amplifier suggests a 3-MHz/volt tuning sensitivity. If the microwave oscillator is unstable or drifts (necessitating a greater tuning range), an ECL divide-by-2 or divide-by-4 could be inserted right at the phase comparator input. Of course, this would produce a different locked output frequency, and all other i-f and oscillator frequencies in the system might have to be reselected. The loop filter component values would also have to be recomputed.

Selection of the 10-GHz oscillator depends upon

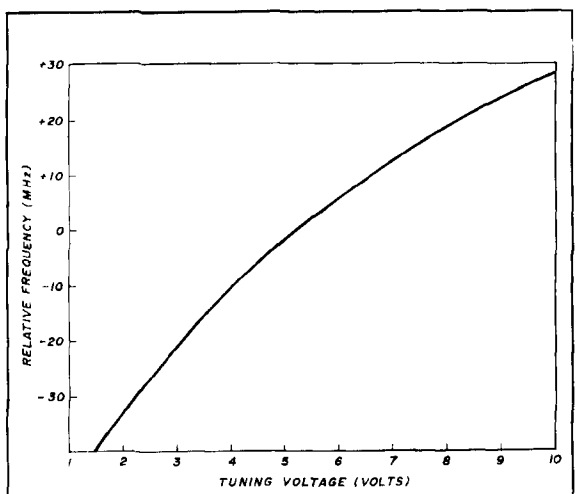


fig. 12. Measured tuning curve for a M/A-Com Gunnplexer™. The curve is fairly straight indicating nearly constant tuning sensitivity, particularly in the 4-10 volt region.

what is available and within your budget. The M/A-Comm Gunnplexers™ work extremely well and require very little additional circuitry. If you have one of these as part of a wideband station, you may want to use the 10,220-MHz locking scheme. If there is already some broadband 10-GHz activity in your area and you

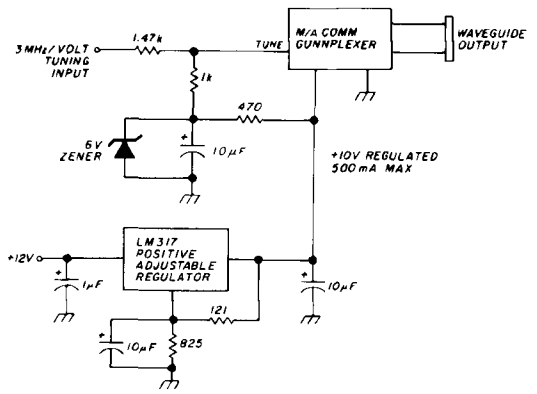


fig. 13. A three-terminal regulator provides clean bias for the Gunnplexer. A Zener diode and two resistors provide an offset and scale the tuning to the approximately 3-MHz/volt sensitivity required for the common phaselock board.

don't want to give it up entirely, this approach will allow switching between modes. The Gunnplexer can be operated with its internal diode mixer for operation on 10220/10250 wideband duplex, or phase locked to 10220 and used with a 148-MHz SSB transceiver for 10368-MHz narrowband weak signal work. The wideband station can also be run phase locked with modulation of the 20-MHz reference signal in the 1020-MHz loop phase. (This should end any local discussions about who is or is not on the right frequency!)

The M/A-Comm Gunnplexers have electronic tuning and need only level shifting and scaling of the tuning voltage. A typical tuning curve for a GunnPlexer is shown in **fig. 12.** Driving the tuning input directly from the loop amplifier provides too much tuning range and could allow "latch-up" on the wrong side of the i-f, as mentioned before. It is a simple matter to scale the tuning input to reduce the approximately 7-MHz/volt sensitivity down to about 3. A circuit providing this scaling, as well as a regulated 10-volt bias supply, is shown in **fig. 13.** This circuit will maintain proper output and tuning even when the power supply voltage drops slightly below 12 volts. A low dropout regulator may be substitued for the LM317K for particularly low inputs. This is of concern primarily when mountain topping with discharged batteries as the only power source! The phase-locked Gunnplexer produces an excellent 10080-MHz signal (**fig. 14**).

Some means of tuning must be provided if an oscillator without an electronic tuning input is used. The Gunn oscillators in automatic door openers can be made to work by using bias voltage "frequency pushing". These are very similar to Gunnplexers except for their lack of electronic tuning and a mixer diode. The tuning deficiency can be overcome by using the bias/tuning circuit in **fig. 15.** Here a three-terminal regulator sets the bias and tunes the oscillator for phase locking. To pick the nominal bias point, plot a frequency versus bias voltage curve for your particular oscillator — this will vary from oscillator to oscillator. Usually a range of bias can be found (often just on one side of maximum power output) that provides a fairly straight tuning curve or nearly constant tuning sensitivity. A plot of a typical bias-tuned oscillator is shown in **fig. 16.** The tuning resistor values are selected to tune over a 24-MHz range with 2 to 10 volts on the tune input. The nominal operating

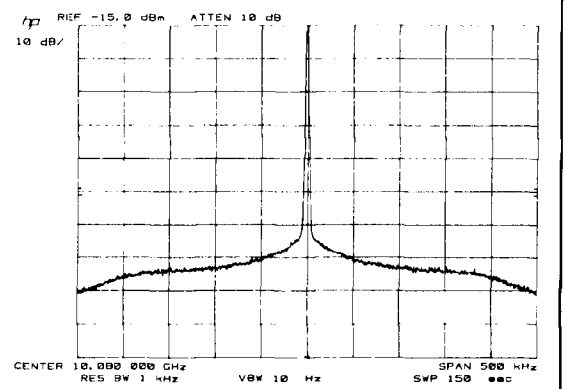
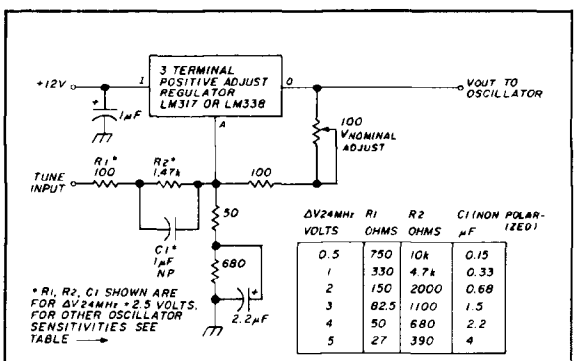


fig. 14. Signal produced by the phaselocked Gunnplexer.



ΔV24MHz VOLTS	R1 OHMS	R2 OHMS	C1 (NON POLARIZED) μF
0.5	750	10k	0.15
1	330	4.7k	0.33
2	150	2000	0.68
3	82.5	1100	1.5
4	50	680	2.2
5	27	390	4

fig. 15. An adjustable three-terminal positive regulator can both bias and tune a surplus Gunn oscillator via "frequency pushing", the oscillator's frequency/bias voltage dependency. The table shows alternate component values for different "push-tuning" sensitivities. Part of the voltage setting and tuning resistance is bypassed to reduce noise on the regulator output.

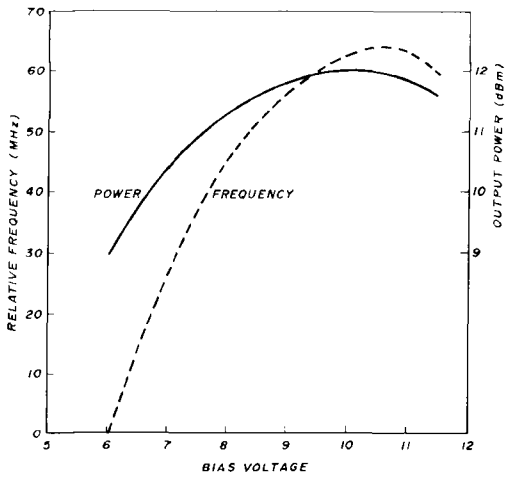


fig. 16. This is a tuning curve of a surplus Solfan™ oscillator of the type used in burglar alarm motion detectors and automatic door openers. Both output power and frequency are dependent upon bias voltage. By plotting a similar curve and selecting a useful portion of the tuning curve, you can find component values for biasing and tuning almost any similar oscillator. In this case, a bias of 8.25 volts + 1.25 volts will tune the output over approximately a + 12-MHz tuning range.

point, with 6 volts applied to the tuning input, is set at the center of this range. If 24-MHz tuning is not possible, use the maximum available and recalulate the PLL component values for the different tuning sensitivity.

The three terminal regulators work in this application because they have several hundred kHz of bandwidth and can follow a 50-kHz bandwidth error signal without adding much additional phase shift. This is necessary for the loop to remain stable. The regulators do add some noise to the oscillator output when used in this configuration; reduction of this is the reason for splitting up and bypassing part of the voltage setting and tuning resistances. This technique is not the ultimate in low phase noise performance, but the −90 dBC noise sidebands obtainable (1 Hz bandwidth) are more than adequate for Amateur use and will probably never be observed unless signal strengths are 30 or more dB above S9. The Gunnplexers, with their built-in tuning, will probably be at least 8 to 10 dB cleaner than this. Although I have not tried them, many of the oscillators in automotive radar detectors should work well. Another source of suitable oscillators is the type used for police radar guns. The NEC ND751AAM for 10 GHz (ND610AAM for 24 GHz) has similar characteristics. Any of these 10-GHz sources should have adequate drive power for the signal mixer described next.

The oscillators' output and antenna connections need to be in coax in order to use the downconverter and mixer. Although waveguide is well behaved and very low in loss, coax is versatile and convenient. I have used coax throughout the 10-GHz station, both at 1 and 10 GHz. Miniature SMB "snap on" connectors work well at 1 GHz and below, even when used with poor quality lossier coax cable. In the microwave region, 0.086-inch semi-rigid cable is a pleasure to work with; the cable and corresponding SMA connectors are fairly easy to find. To cut the cable to length, first score the outer conductor with a sharp knife; then grab each side of the score mark with a pair of needle-nose pliers and break. The Teflon dielectric can be trimmed away and the cable end slid into the connector or soldered directly to the circuit, depending upon the application.

If your oscillator is similar to the door-opener type, it probably has a waveguide output and will require a waveguide-to-coax adaptor. These are often available as surplus but if you don't have or can't get one, it is easy to build an acceptable substitute. The version shown in **fig. 17** made from a short length of commercial waveguide works very well, although you'll need metal-working equipment. If your shack doesn't include much more than a soldering iron, hacksaw, and file, the second version made from pc board in **fig. 18** is for you.

After selecting your 10-GHz oscillator, build the appropriate tuning circuit. If a means of measuring 10-GHz frequency (a 10-GHz counter or spectrum analyzer with 1-MHz frequency resolution) is not avail-

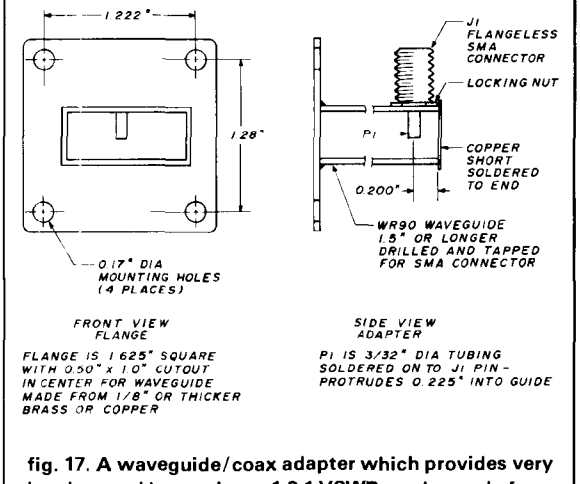


fig. 17. A waveguide/coax adapter which provides very low loss and better than a 1.2:1 VSWR can be made from a short length of standard WR90 waveguide. A standard SMA connector is threaded into a hole in the broad wall of the guide located 0.200 inch from the shorted end. A flange made from a suitably stiff piece of brass or copper is soldered to the other end.

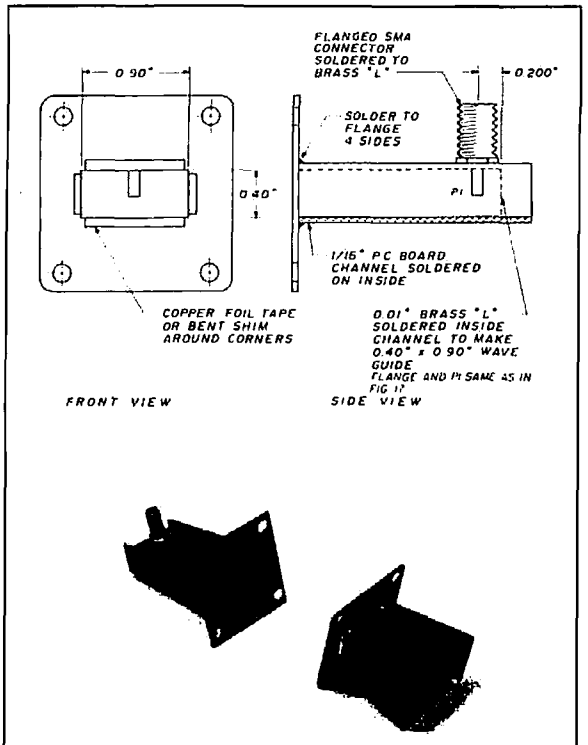


fig. 18. If metal-working equipment necessary to fabricate the adapter shown in *fig. 17* is not available, an acceptable substitute can be made from standard 1/16-inch pc board and brass shim stock. A channel is first made from the board material and then the brass top/short is soldered. Continuity from the inside of this homebrew waveguide to the front of the flange is provided by sticky copper foil tape.

able, you may use the 10-GHz downconverter and locked 1010-MHz source to determine oscillator operating frequency. An old general coverage receiver with poor selectivity is great for this, because an unstable signal is easy to hear as it drifts past. Take the same precautions mentioned earlier to avoid overload. When you do hear a signal, verify that it is on the correct side of the 1010-MHz reference harmonic at 10.1 GHz by making sure that the i-f signal is tuning lower as you tune the microwave oscillator higher. Use mechanical tuning for this because (unless you have a M/A-Comm or other "known" oscillator) you can't be sure what the sense of the electronic tuning is. If the tuning characteristics are unknown, use your general coverage receiver or low-frequency counter on the PLL i-f to plot a tuning curve as a function of the oscillator bias voltage. A few oscillators will "mode" and jump frequency, particularly when not properly matched and operated at extremely low or high biases. A nominal operating point between 6 and 10 volts is appropriate for most oscillators I have tried. Select the nominal bias voltage as the center of a reasonably straight 24-MHz range near the maximum power bias point, or in a mode-free region. Select the tuning scaling resistors from **fig. 15** based on the change in bias necessary to produce 24-MHz frequency change; this gives 3-MHz/volt sensitivity at the tuning input. The sense of this tuning may be either positive or negative, depending on your particular oscillator. For the motion detector oscillator plotted in **fig. 16** I chose a nominal bias point of 8.25 volts. Tuning resistor values were selected for the required volt change (approximately 2.5). These values cause the 2 to 10 volts from the loop amplifier to tune the oscillator over a 24-MHz total range. Resistor and capacitor values for some different oscillator sensitivities are shown in the table.

When you are confident that the oscillator is tuning correctly, preset it to 10080 MHz with 6 volts on the bias circuit tuning input. Do this by coarse tuning for a 20-MHz PLL i-f on the correct side of 10100 MHz. If the PLL board is functioning, locking should now be no more difficult than locking the 1010-MHz oscillator. Remember to select the proper wire jumpers based on "high side" LO and the tuning direction of your particular oscillator.

As for the 1010 MHz oscillator, troubleshoot any problems by separating the PLL components and testing them individually. Make sure that the PLL board works on a lower frequency loop. Verify that there are suitable 1-volt peak-to-peak ECL levels on both phase

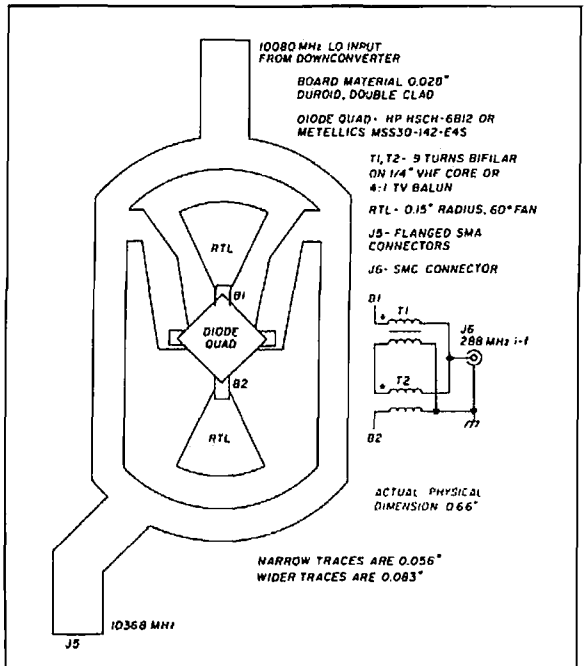


fig. 19. Closeup of the 10-GHz signal mixer.

comparator inputs. Also make sure that the 10-GHz oscillator is tuning properly. Be sure that there is no large (bigger than 1000 pF) bypass capacitor across its bias input; this could limit the fm bandwidth.

signal mixers

Commercial mixers that give good performance up through 2304 MHz are available at reasonable prices. Simple "rat race" mixers can be made on Teflon pc board for all bands up to and including 10 GHz; they don't work as well at 24 GHz and above because of packaged diode size and parasitics. A diode mixer with less than 7-dB conversion loss at 10368 MHz (with 10080-MHz local oscillator injection) can be cut out of a piece of circuit board. This by itself (no amplifier, preamplifier, or transmit/receive switch) can give S9 signals between similar stations with 4-foot dishes separated by 10 miles!

The 10-GHz signal mixer uses the same diode ring and board material as the 10-GHz harmonic downconverter. Building it on the same piece of board material eliminates two connectors and some coax along with their associated losses. A balun is used to match the mixer diode's i-f impedance to 50 ohms. You can make this balun from two toroidal cores, or use a VHF TV 300-to-75 ohm balun. Conversion loss of under 10 dB should be possible over a range of local oscillator powers. Low barrier diodes are indicated in the parts list, but medium and high barrier may be substituted if sufficient 10080-MHz oscillator power is available. Higher drive levels make higher i-f levels possible on transmit, and therefore higher 10368-MHz transmit power. To avoid serious distortion, i-f power should generally be kept at least 10 dB below the available local oscillator power. A close-up of the 10-GHz signal mixer is shown in **fig. 19**.

Build the signal mixer as part of the downconverter assembly, and you can be on the air as soon as the 10-GHz oscillator is locked and you have a suitable SSB i-f transceiver. Just hook it through a bandpass filter to your antenna!

Part 3 will discuss the following: a 260-MHz locked oscillator along with amplifiers and switching for the 280-290 MHz i-f transverter; and a two-stage, 16-dB gain, 2.5-dB noise figure 10-GHz amplifier that can be used on transmit and receive. Two such stations connected to modest size antennas should improve your DX possibilities and could help you break the current world 10-GHz DX record!

ham radio

the HAM STATION

P.O. Box 4405
220 N. Fulton Ave.
Evansville, IN 47710

Store Hours
MON-FRI: 9AM - 6PM
SAT: 9AM - 3PM
CENTRAL TIME

SEND A SELF ADDRESSED STAMPED ENVELOPE (SASE) FOR NEW AND USED EQUIPMENT SHEETS

WARRANTY SERVICE CENTER FOR: ICOM, YAESU, TEN-TEC

FOR SERVICE INFORMATION CALL (812) 422-0252
MONDAY - FRIDAY
9:00 AM - 12:00 NOON

YAESU



FT-747GX
- 100 Watts of Economical Performance
- Dual VFO's, 20 Memories
- Receives from 100 kHz-30 MHz
- Built-In CW Filter + More

ICOM



IC-761
- Top-Of-The-Line High Performance HF Transceiver
- Built-In Power Supply
- Built-In Automatic Antenna Tuner
- SSB, CW, FM, AM, RTTY
- 160-10m General Coverage Receiver

TEN-TEC

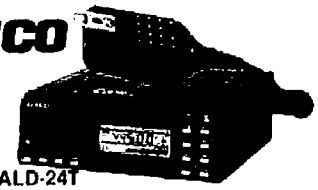


PARAGON
- Full Featured Synthesized HF Transceiver
- General Coverage Receiver
- 100w Output
- SSB, CW, FSK, Optional FM
- 62 Programmable Memories
- Made In USA

YAESU ALINCO

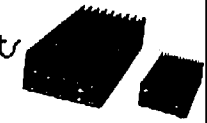


FT-727R
- Two Affordable Radios In One
- 2m/440 MHz Handheld
- 5W on Both Bands
- Ten Memories
- Multi-Scan Systems
- Battery Saver



ALD-241
- Dual Band Mobile 140-149.995 MHz/ 440-450 MHz
- 21 Programmable Memories
- 25 Watts Output on Both Bands
- Loaded with Extra Features

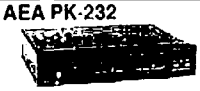
dconcepts VHF/UHF AMPS



- High VSWR and Overdrive Protection
- 5 Year Warranty, 6 Months on RF Transistors
- All Units have GaAsFET Receive Pre-amps

TERMS:
Prices Do Not Include Shipping.
Price and Availability Subject to Change Without Notice
Most Orders Shipped The Same Day
COD's Welcome

AEA PK-232



Data Controller with 6 Modes

Packet	ASCII
Morse Code	AMTOR
Baudot (RTTY)	Weather Fax

List $319.95 Now Special Priced

SPECIAL
MFJ 989B
3 KW Tuner
$295.
- SWR/Wattmeter
- Antenna Switch
- Built-In Dummy Load



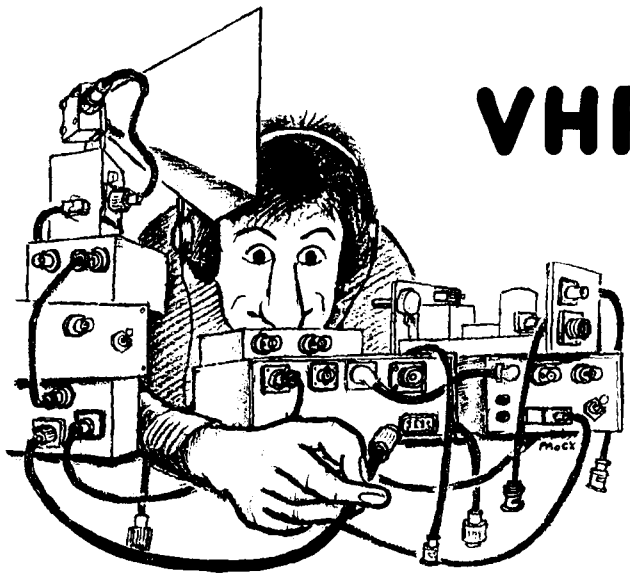
Kantronics

NEW!
- 5 Monoband Transceivers
- Models for 80, 40, 20, 15, 10 M
- Single-Sideband & CW
- 20 Watts PEP
- Weigh less than 2 lbs.

Call Today for Introductory Price

For Orders and Price Checks Call 800-523-7731

Indiana and Information
Call 1-812-422-0231



VHF/UHF WORLD

Joe Reisert, W1JR

propagation update—part 2

I've discussed VHF/UHF/microwave and millimeter-wave radio propagation many times in this column,[1-6] yet there is always more new material available. This month we will try to pick up where **reference 3** left off and update the present state of the art (SOA) of radio propagation above 50 MHz.

DX records

For years I have felt that the greatest incentives for experimentation on the frequencies above 50 MHz are discovering new propagation modes and setting new DX records. However, published DX records were either scattered or incomplete and often without any mention of the propagation mode used. Most of the published records were worldwide, tending to favor regions where special geography or phenomena are present.

Several years ago I started publishing consolidated VHF/UHF/microwave and millimeter-wave DX records in "VHF/UHF World." At first only the more available worldwide records were included.[1] Later EME (Earth-Moon-Earth) records were added.[2]

I next published a list including only those DX records where at least one of the stations was located in North America. As a new twist, the suspected propagation mode was added.[2] This made for many new DX opportunities above 50 MHz.

The "North America Only" list caught on like wildfire. Many new DX record claims were documented and other propagation modes on different frequency bands were added. These records have been published at least once a year in this column; we now publish new record claims at the end of each "VHF/UHF World."

This month is no exception. All three record tables have been updated. **Table 1** shows the North America Only terrestrial records, **table 2** lists the worldwide terrestrial records, and **table 3** the worldwide EME records.

Each claim has been documented by at least one of the record holders. To facilitate new claims, I designed the VHF/UHF/SHF Record Verification Form in **table 4**. The form verifies when the claimed contact took place and shows the equipment required to make the record. The latter is particularly important since it sets the minimum equipment specifications required.

frequency bands

The list of frequencies available to Amateurs under FCC jursidiction was published in **reference 2**; the microwave and millimeter frequencies were later updated and appeared in **reference 3**. There haven't been any changes of late.

However, there are some further frequency restrictions. The band most affected is the 70 cm (420-450 MHz). Any United States station operating within 100 miles of any PAVE PAWS radar installation and running more than 50 watts is required to obtain FCC permission. This currently affects Amateurs in New England, Georgia, Texas, Alaska, and California.

Amateurs operating in the 70-cm band near the missile test ranges in California, Florida, and New Mexico are also affected by the new rules. There have been additional restrictions placed on Amateurs operating in the 420-430 MHz region near the Canadian border and some Canadians are now affected in the 430-450 MHz region near airports using experimental windshear radar. These rules seem to be in a state of flux.

At the present time, Amateur restrictions on 33 cm (902-928 MHz) are

Table 1. North American VHF and Above Claimed DX Records. (Notes 1, 2 & 3)

Frequency	Record Holders	Date	Mode	DX Miles	(km)
50 MHz	Note 4				
EME	WA4NJP (EM84DG)-KH6HI (BL01XH)	88-02-15	CW	4530	(7289)
144 MHz					
Aurora	KA1ZE (FN31TU)-WB0DRL/WA0TKJ (EM18CT)	86-02-08	CW	1347	(2167)
Ducting	KH6GRU (BL01XH)-WA6JRA (DM13BT)	73-07-29	CW	2586	(4161)
EME	VE1UT (FN63XV)-VK5MC (QF02EJ)	84-04-07	CW	10,985	(17676)
Spor. E	KD4WF (EM92LA)-NW70/7 (DM25GV)	87-06-14	SSB	1980	(3186)
FAI	W5HUQ/4 (EM90GC)-W5UN (DM82WA)	83-07-25	CW	1228	(1976)
MS	K5UR (EM35WA)-KP4EKG (FK68VG)	85-12-13	SSB	1960	(3153)
TE	KP4EOR (FK78AJ)-LU5DJZ (GF11LU)	78-02-12	SSB	3933	(6328)
Tropo	K1RJH (FN31XH)-K5WXZ (EM12QW)	68-10-08	CW	1468	(2362)
220 MHz					
Aurora	W3IY/4 (FM19HA)-WB5LUA (EM13QC)	82-07-14	CW	1145	(1842)
Ducting	KH6UK (BL11AQ)-W6NLZ (DM03TS)	59-06-22	CW	2539	(4086)
Spor. E	K5UGM (EM12MS)-W5HUQ/4 (EM90GC)	87-06-14	CW/SSB	932	(1499)
EME	K1WHS (FM43MK)-KH6BFZ (BL11CJ)	83-11-17	CW	5058	(8139)
MS	K1WHS (FM43MK)-K0ALL (EN16NW)	85-08-12	SSB	1279	(2057)
TE	KP4EOR (FK78AJ)-LU7DJZ (GF05RJ)	83-03-09	CW/SSB	3670	(5906)
Tropo	VE3EMS (EN86QJ)-WB5LUA (EM13QC)	82-09-28	SSB	1181	(1901)
432 MHz					
Aurora	W3IP (FM19PD)-WB5LUA (EM13QC)	86-02-08	CW	1182	(1901)
Ducting	KD6R (DM13NI)-KH6IAA/P (BK29GO)	80-07-28	CW	2550	(4103)
EME	K2UYH (FN20QG)-VK6ZT (QF78VB)	83-01-29	CW	11,567	(18612)
MS	W2AZL (FN20VI)-W0LER (EN35IA)	72-08-12	CW	1019	(1640)
Tropo	WB3CZG (FN21AX)-WA5VJB (EM12LO)	86-11-29	SSB	1318	(2121)
903 MHz					
EME	K5JL (EM15DQ)-WB5LUA (EM13QC)	88-02-07	CW	187	(301)
Tropo	W2PGC (FN02OR)-K3SIW/9 (EN52WA)	86-12-24	SSB	478	(769)
1296 MHz					
Ducting	KH6HME (BK29GO)-WB6NMT (DM12KU)	86-08-13	SSB	2528	(4068)
EME	K2UYH (FN20QG)-VK5MC (QF02EJ)	81-12-06	CW	10,562	(16995)
Tropo	WB3CZG (FN21AX)-KD5RO (EM13PA)	86-11-29	CW	1287	(2070)
2304 MHz					
EME	W3IWI/8 (FM08CK)-ZL2AQE (RE78JS)	87-10-18	CW	8658	(13931)
Tropo	KD5RO (EM13PA)-W8YIO (EN82BE)	86-11-29	CW	940	(1513)
3466 MHz					
Tropo	WA5TNY/5 (EM11AU)-WB5LUA/5 (EM24UQ)	86-10-19	CW	288	(464)
EME	W7CNK/5 (EM15FI)-K0KE/0 (DM79NO)	87-04-12	CW	498	(802)
5760 MHz					
Tropo	K5PJR (EM26OP)-W5UGO/0 (EN00PH)	87-07-04	CW	332	(535)
EME	WA5TNY (EM12KV)-W7CNK/5 (EM15FI)	87-04-24	CW	174	(279)
10.368 GHz					
Tropo	N6GN/6 (CM89PX)-W6SFH/6 (DM04MS)	87-07-19	CW	414	(666)
24.192 GHz					
LOS	WA3RMX/7 (CN93IQ)-WB7UNU/7 (CN95DH)	86-08-23	SSB	116	(186)
47.040 GHz					
LOS	WA3RMX (CN85PL)-WB7UNU/W7TYR (CN85NH)	87-03-08	SSB	13.9	(22.4)
76-149 GHz	None reported				
474 THz					
LOS	K6MEP (DM04IO)-WA6EJO (DM04KT)	79-06-09	LASER	15	(24)

Note 1. The records are listed alphabetically by mode. Ducting is suspected where the path is mostly over water. No efforts are made to separate out ducting on overland paths so they're grouped under tropo.

Note 2. The information within the parentheses ( ) following the callsign is the grid square locator.

Note 3. Distances have been calculated assuming a spherical earth model using the actual latitude and longitude rather than grid square centers which are less accurate.

Note 4. Six-meters records, excepting EME, were left off since the primary propagation mode is often hard to distinguish. Also long-path QSOs have been reported during solar cycles 19 and 21 which exceed approximately 12,430 miles.

Table 2. Worldwide Claimed VHF/UHF/SHF Terrestrial DX Records (notes 1 & 2)

Frequency	Record Holders	Date	Mode	DX Miles	(km)
50 MHz	Note 3				
70 MHz	GW4ASR/P (IO82JG)-5B4CY (KM64MR)	81-06-07	Es	2153	(3465)
144 MHz	I4EAT (JN54VG)-ZS3B (JG73OI)	79-03-30	TE	4884	(7860)
220 MHz	KP4EOR (FK68XM)-LU7DJZ (GF05RJ)	83-03-09	TE	3670	(5906)
432 MHz	KD6R (DM13NI)-KH6IAA/P (BK29GO)	80-07-28	Duct	2550	(4103)
903 MHz	W2PGC (FN02OR)-K3SIW/9 (EN52WA)	86-12-24	Tropo	478	(769)
1296 MHz	KH6HME (BK29GO)-WB6NMT (DM12KU)	86-08-13	Duct	2528	(4068)
2304 MHz	VK5QR (PF95HD)-VK6WG/P (OF85WA)	78-02-17	Duct	1170	(1883)
3456 MHz	VK5QR (PF95HD)-VK6WG (OF85WA)	86-01-25	Duct	1171	(1885)
5670 MHz	G3ZEZ (JO01MS)-SM6HYG (JO58RG)	83-07-12	Duct	610	(981)
10.3 GHz	I0SNY/EA9 (IM75IV)-I0YLI/IE9 (JM68NR)	83-07-08	Duct	1032	(1660)
24 GHz	I0SNY/IC8 (JN60WR)-I8YZO/8 (JM78WE)	84-08-11	LOS	206	(331)
47 GHz	HB9AGE/P (JN36FS)-HB9MIN/9 (JN36SX)	87-06-06	LOS	53.5	(86)
75 GHz	HB9AGE/P (JN37RD)-HB9MIN/P (JN37RD)	85-12-30	LOS	0.3	(0.5)
474 THz	K6MEP (DM04IO)-WA6EJO (DM04KT)	79-06-09	LOS	15	(24)

Notes:
1. The information within the parentheses ( ) after the callsign is the grid square locator.
2. Distances have been calculated assuming a spherical earth model. The actual latitude and longitude are used rather than grid square centers which are less accurate.
3. Six meters has been left blank on this listing because long-path QSOs (those exceeding approximately 12,430 miles) have been reported during solar cycles 19 and 21.

Table 3. Worldwide Claimed VHF/UHF/SHF EME DX Records (notes 1 & 2)

Frequency	Record Holders	Date	Mode	DX Miles	(km)
50 MHz	WA4NJP (EM84DG)-KH6HI (BL01XH)	88-02-15	CW	4530	(7289)
144 MHz	K6MYC/KH6 (BK29AO)-ZS6ALE (KG43RC)	83-02-18	CW	12,091	(19455)
220 MHz	K1WHS (FN43MK)-KH6BFZ (BL11CJ)	83-11-17	CW	5058	(8139)
432 MHz	F9FT (JO29AG)-ZL3AAD (RE66GR)	80-04-18	CW	11,679	(18793)
902 MHz	K5JL (EM15DQ)-WB5LUA (EM13QC)	88-02-07	CW	187	(301)
1296 MHz	PA0SSB (JO11WI)-ZL3AAD (RE66GR)	83-06-13	CW	11,595	(18657)
2304 MHz	W3IWI/8 (FM08CK)-ZL2AQE (RE78JS)	87-10-18	CW	8658	(13931)
3456 MHz	W7CNK/5 (EM15FI)-K0KE (DM79NO)	87-04-06	CW	498	(802)
5670 MHz	WA5TNY (EM12KV)-W7CNK/5 (EM15FI)	87-04-24	CW	174	(279)

10,000 MHz and above: None reported

Notes:
1. The information within the parentheses ( ) following the callsigns is the grid square locator.
2. The distances shown have been calculated assuming a spherical earth model. The actual latitudes and longitude are used rather than grid square centers which are less accurate.

still in effect in Colorado, Wyoming, White Sands Missile Range, and Region 3 areas. Operators in these restricted areas who have tried to obtain permission from the FCC have been unable to do so. Canadian Amateurs need special permission from DOC to use CW or SSB on this band. (It is presently designated as fm only!)

solar cycle update

Probably one of the hottest discussions on the hf and 6-meter bands these days is "when will the next solar cycle peak?" Near the sunspot peak there is a chance that F2 propagation will be possible on 6 meters. News of that peak is starting to come in. The smoothed sunspot count of Cycle 21 peaked at 164.5 in December of 1979 and ended when it bottomed out at 12.3 sunspots in September 1986. The new cycle, 22, has definitely begun and no one knows for sure how high the peak will be or when it will occur.

Improved methods of forecasting like the Sargent/Ohl[7] were very close in predicting the peak of cycle 21. Based on available data and using this prediction method[8], it now appears that cycle 22 will peak at a smoothed level of 118.6 sunspots in mid-1991. **Figure 1** shows this early data along with the final data on cycle 21.

The predicted peak of cycle 22 shows that it will be very flat and should stay above 100 sunspots from about July 1989 through June 1992. Because this cycle started statistically

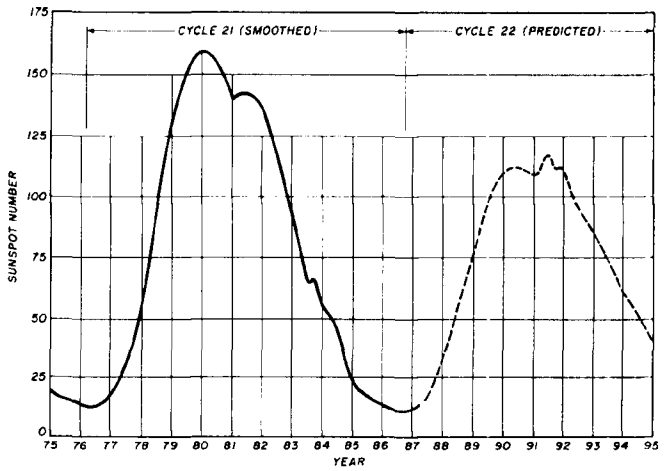


fig. 1. This graph shows the smoothed sunspot numbers for solar cycle 21 as well as the forcasted numbers for cycle 22, per reference 8.

backscatter

The backscatter form of propagation described in **reference 1** is basically a form of reflection and indicates that a highly ionized region is present. Operators detecting this phenomenon can often work DX by aiming their antennas in the direction of the ionized region and "backscattering" their signals.

Backscatter also indicates that the MUF is very high; it was well used during solar cycle 21 to indicate the presence of an opening. Often western United States stations could work Hawaii while eastern stations could work Europe either by backscatter or by knowing that there was a high degree of probability of an opening in progress.

earlier than other cycles and rose abruptly, we will have to wait at least another year or so to see what if any modifications will occur.

This information is not very promising for 6-meter Amateurs as it usually takes a sunspot count above 150 to yield good F2 openings. However, minor sunspot peaks often occur during a cycle, albeit of short duration. No 6-meter operator active during the last solar cycle will ever forget the solar peaks in late 1979 that rivaled those of all previously recorded solar cycles.

The equivalent short-term sunspot number can be predicted using the solar flux measured at Ottawa on 10.7 cm. The value is updated daily and broadcast at 18 minutes after each hour on radio station WWV. Using the equation shown in **reference 2**, I have prepared **fig. 2** which can be used to determine the equivalent sunspot number on any day. Remember also that the ionosphere usually has to be "pumped up" for four or five consecutive days to yield good long-haul F2 propagation.

The SOA in equipment, antennas, and propagation forecasting has greatly improved in recent years. Predictions of the MUF are now possible with improved accuracy using personal computer programs like MINIMUF[8] in conjunction with the sunspot number per **fig. 2**.

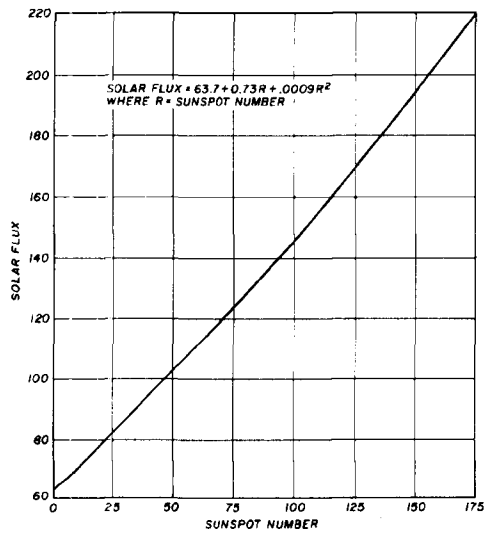


fig. 2. This figure shows the correlation between solar flux and sunspot numbers.

This information, along with increased 6-meter interest and improved operating methods (more on this shortly), as well as recent relaxations in licensing restrictions in western Europe and North Africa, means that there will be many more regions and DXCC countries represented during cycle 22. Let's hope it's a great cycle for 6-meter operators. Stay tuned!

Look for backscatter especially over the Atlantic and Pacific Oceans. It can also be observed on 10 meters to indicate a possible 6-meter opening. Backscatter will become much more evident as the sunspots increase and is usable up through 6 meters.

ionospheric scatter

Ionospheric scatter was also described in **reference 1**. It is a form of "forward scatter" linked to the time

Table 4. VHF/UHF/SHF Propagation Record Verification Form.
(Please return to Joe Reisert, W1JR, 17 Mansfield Drive, Chelmsford, MA 01824)

Band:_____ Propagation Mode:_____ Date of record (UTC):_____

Time of record (UTC):_____ DX (miles)_____ (km):_____

Station 1	**Station 2**
Call:_____	Call:_____
Name:_____	Name:_____
QTH for this QSO:_____	QTH for this QSO:_____
Lat*:_____ Long*:_____	Lat*:_____ Long*:_____
Grid Locator (6 digit):_____	Grid Locator (6 digit):_____
Elevation ASL (feet):_____ (meters):_____	Elevation ASL (feet):_____ (meters):_____
Location description:_____	Location description:_____
Antenna type:_____	Antenna type:_____
Estimated gain (dBi):_____	Estimated gain (dBi):_____
TX freq:_____	TX freq:_____
TX power:_____	TX power:_____
Feedline loss:_____	Feedline loss:_____
Modulation type:_____	Modulation type:_____
RX freq:_____	RX freq:_____
RX type:_____	RX type:_____
RX desc:_____	RX desc:_____
Feedline loss:_____	Feedline loss:_____
Noise figure:_____	Noise figure:_____
RX bandwidth:_____	RX bandwidth:_____
Rcvd signal to noise ratio:_____	Rcvd signal to noise ratio:_____
Other equipment description:_____	Other equipment description:_____

Other comments, weather conditions etc:_____

The information submitted above is correct to the best of my knowledge.

Submitted by:_____ Call:_____ Home QTH:_____

_____ Phone number (AC_____)_____

Record received and verified by:_____ Date:_____

*Please list latitudes and longitudes in degrees, minutes, and seconds.

of day (typically peaking broadly around noon local time) and to high sunspot activity. Ionospheric scatter can be used on 6 and 2 meters.

This form of propagation is used extensively in commercial service but seems to have been almost totally ignored by Amateurs. It does require reasonable antenna gain and high power, but is within the reach of many well-equipped 2-meter Amateur stations, especially those with EME or marginal EME capability.

As the sunspots increase, so will the possibilities of forward scatter. This represents an interesting challenge for Amateurs and is a good way to increase their grid square count in the 800-1300 mile region.

TE (transequatorial) scatter

Like forward and back scatter, TE propagation is a good mode for long DX, especially on 6 meters. It is best observed across the equator on more or less directly north-south paths with typical distances of 3 to 6,000 miles.

TE propagation is most often observed in the late afternoon and early evening for several weeks around the equinoxes. During the peak of the solar cycle around this time, highly ionized "patches" are often present approximately 10-20 degrees north and south of the "geomagnetic" equator.

Unfortunately, the geomagnetic equator is very far south in the North and South American sector. This limits North American TE propagation mainly to stations in the Caribbean and the extreme southern portions of the United States. Don't let this discourage you; there are always new propagation modes and isolated openings to explore.

equatorial FAI (Field Aligned Irregulatities)

Equatorial FAI was first discovered in 1977.[10] It is still not fully understood and often referred to as TE propagation (see **references 11** and **12**). Like TE scatter, equatorial FAI depends on highly ionized patches that are typically located 10-15 degrees north and south of the geomagnetic equator at the same dates and times discussed under TE propagation above. However, the DX is slightly less. The most favored locations are paths from southern Europe to South Africa, Japan to Australia, and the Caribbean to southern South America.

While TE scatter is generally limited to below 100 MHz, equatorial FAI has been known to extend higher in frequency. Contacts as high as 220 MHz have been confirmed as shown in **tables 1** and **2**. Although some one-way 432 reports have been reported, I have been unable to document any two-way contacts above 220 MHz. Maybe during the peak years of solar cycle 22 the frequency barrier will be broken and two-way 432 MHz contacts will be completed. Any takers?

midlatitude FAI

When **reference 10** was written, it was speculated that FAI propagation would be possible in mid-northern latitudes. It didn't take long before this became a reality on 144 MHz.[13]

Midlatitude FAI propagation has many similarities to auroral propagation; both stations must be south of the ionized region and aim their antennas several degrees north of the great circle path. This type of propagation most often occurs in the evenings during the summer, especially on days when there has been sporadic E propagation on 6 meters. As shown in table 1, it has been successfully used out to a distance of just over 1200 miles on 2 meters. Until recently FAI has been slow to take hold, despite the fact that it should be usable up through 220 MHz.[13]

This is all changing now — contacts were reported during the summer of 1987 in the southern United States and a wide region of Europe (**reference 14** through **16**). In fact, well over 500 European contacts were reported using midlatitude FAI propagation during the summer period of 1986 alone! (See **reference 15.**)

As observed in Europe, the scatter region tends to be at the same height as sporadic E, typically 70 miles. These regions resemble aurora propagation; unlike the relatively small (1-2 mile thick) sporadic E clouds, they have large volume areas.

Midlatitude FAI signals tend to have rapid fading. They have been observed over several European locations but mostly along the 45-55 degree north latitude lines following the contours shown in **reference 13.** Those who can elevate their antennas have a greater possibility of success.

Midlatitude FAI propagation offers a great challenge to VHF Amateurs, especially in North America. This mode of propagation should be usable up through 220 MHz throughout the contiguous 48 United States. All it takes is some patience and a surge in activity. Who will be the first to report a 220-MHz midlatitude FAI QSO? It's there for the asking!

summary

This month I've given you a status report on the latest DX records on the VHF/UHF/microwave bands. We've also discussed the latest prognosis for propagation using the solar cycle 22 peak and some scatter modes. Next month's column will update other propagation modes. Until then, you can read the references cited.

new DX records

This has been a good month for new VHF/UHF DX records. First off, the 6-meter EME record has been extended. On February 15, 1988 between 1800-1845 UTC, Ray Rector, WA4NJP, Gillsville, Georgia (EM84DG) completed a two-way EME contact with Bert Ingalls, KH6HI, Ewa Beach, Hawaii (BLØ1XH), on 50.008 MHz using 1-minute sequencing. The distance was approximately 4530 miles (7289 km). Ray was using 1500 watts and Bert was running 1000. Both stations were using quads of four eight-element Yagis on 35-38 foot booms. Congratulations to Ray and Bert — 6 meters is now buzzing with EME activity.

Last month we reported the first ever 33-cm (902 MHz) EME QSO. That record didn't last very long! On February 7, 1988 at 0500 UTC, Jay Lieb-

mann, K5JL, Piedmont, Oklahoma (EM15DQ) completed a 33-cm EME QSO with Al Ward, WB5LUA, McKinney, Texas (EM13QC) over a distance of approximately 187 miles (301 km). Both stations were running approximately 150 watts and 24-28 foot dishes. Congratulations, Jay and Al. It looks as if 33-cm EME activity is just about to take off. Both records just discussed are included in **tables 1** and **3**.

Finally (although not yet a DX record), during February 1988 Rick Fogle, Grapevine, Texas (EM12KV) has been heard by Lucky Whitaker, W7CNK, Oklahoma City, Oklahoma (EM15FI) via 3-cm (10,368.1 MHz) EME. Likewise, Lucky has heard Rick via the same path. Rick uses a 10-foot dish and Lucky a 16 footer. Both have their preamplifiers and power amplifiers mounted right at the feed. Unfortunately, they have only one high-power (10-15 watt) TWT amplifier between them which they mail back and forth. Because of this, they can't complete what is considered a conventional two-way QSO (use of two complete sets of gear all used during one operating session). Efforts are underway to get a second power amplifier. Good luck to Rick and Lucky as well as the other 3-cm operators who are also trying to conquer this elusive band. It seems that one of the last EME frontiers is about to be conquered.

important VHF/UHF events

June 4	*EME perigee*
June 7	*Predicted peak of the daytime Arietids meteor shower at 0150 UTC*
June 9	*Predicted peak of the Zeta Perseids meteor shower at 1020 UTC*
June 11-13	*ARRL June VHF QSO Party*
June 14	*New moon*
June 18-19	*SMIRK (Six Meter International Radio Klub) Party Contest (contact KAØNNO)*
June 21	*± 1 month. Peak of midlatitude Sporadic E propagation*
July 1	*± 1 month. Look for United States to Europe openings on 6 meters*
July 2	*EME perigee*
July 13	*New moon*
July 16-17	*CQ Magazine VHF WPX Contest*
July 20	*± 3 weeks. Look for 2-meter Sporadic E openings*
July 21-24	*Central States VHF Conference, Lincoln, Nebraska, NEB (contact WDØDGF)*
July 28	*Predicted peak of the Delta Aquarids meteor shower at 2100 UTC*
July 30	*EME perigee*

references

1. Joe Reisert, W1JR, "VHF/UHF World The VHF/UHF Primer: An Introduction to Propagation," *ham radio*, July 1984, page 14.
2. Joe Reisert, W1JR, "VHF/UHF World-Propagation Update," *ham radio*, July 1985, page 86.
3. Joe Reisert, W1JR, "VHF/UHF World-Microwave and Millimeter Wave Propagation: Part 1," *ham radio*, July 1986, page 82.
4. Joe Reisert, W1JR, "VHF/UHF World-Microwave and Millimeter-Wave Propagation: Part 2," *ham radio*, August 1986, page 69.
5. Joe Reisert, W1JR, "VHF/UHF World-Improving Meteor Scatter Communications," *ham radio*, June 1984, page 82.
6. Joe Reisert, W1JR, "VHF/UHF World-Meteor Scatter Communications," *ham radio*, June 1986, page 68.
7. H.H. Sargent, "Proceedings of the 28th IEEE Vehicular Technical Conference," 1978, page 490.
8. "Preliminary Report and Forecast of Solar Geophysical Data," NOAA, SESC PRF626, September 1, 1987.
9. Robert B. Rose, K6GKU, "MINIMUF: A Simplified MUF-Prediction Program for Microcomputers," *QST*, December 1982, page 36.
10. Joseph H. Reisert, W1JR, and Gene Pfeffer, KØJHH, "A Newly Discovered Mode of VHF Propagation," *QST*, October 1978, page 11.
11. Ray Cracknell, ZE2JV, et al., "The Euro-Asia to Africa VHF Transequatorial Circuit During Solar Cycle 21-Part 1," *QST*, November 1981, page 31.
12. Ray Cracknell, ZE2JV, et al., "The Euro-Asia to Africa VHF Transequatorial Circuit During Solar Cycle 21-Part 2," *QST*, December 1981, page 23.
13. Thomas F. Kneisel, K4GFG, "Ionospheric Scatter By Field-Aligned Irregularities at 144 MHz," *QST*, January 1982, page 30.
14. Guenter Kollner, DL4MEA, "FAI Information," *DUBUS*, 1/87, page 64.
15. Guenter Kollner, DL4MEA, "FAI Information," *DUBUS*, 2/87, page 144.
16. Volker Grassmann, DF5AI, "Reuckstreuungen Ultrakurzer Wellen an Feldlinien-Orientierten Irregularitaten," *DUBUS*, 3/87, page 182.

ham radio

BATTERIES
Nickel-Cadmium, Alkaline, Lithium, Etc.
INDUSTRIAL QUALITY

YOU NEED BATTERIES?
WE'VE GOT BATTERIES!
CALL US FOR FREE CATALOG



E.H.YOST & CO.
EVERETT H. YOST KB9X1
7344 TETIVA RD
SAUK CITY, WI 53583
ASK FOR FREE CATALOG
(608) 643-3194

145

RF POWER TRANSISTORS

We stock a full line of Motorola & Toshiba parts for amateur, marine, and business radio servicing

Partial Listing of Popular Transistors

2-30 MHz 12V (28V)*

P N		Rating	Net Ea.	Match Pr.
MRF421	Q	100W	$24.00	$53.00
MRF422*		150W	36.00	78.00
MRF454, A	Q	80W	14.50	32.00
MRF455, A	Q	60W	11.75	26.50
MRF492	Q	90W	16.00	35.00
SRF2072	Q	65W	12.75	28.50
SRF3662	Q	110W	24.00	53.00
SRF3775	Q	75W	13.00	29.00
SRF3795	Q	90W	15.50	34.00
SRF3800	Q	100W	17.50	38.00
2SC2290	Q	80W	16.75	39.50
2SC2879	Q	100W	22.00	48.00

Q Selected High Gain Matched Quads Available

PARTIAL LISTING OF MISC. TRANSISTORS

BFR96	$2.75	MRF966	2.75
CD2545	16.00	MGF1402	3.75
MRF134	16.00	NE41137	2.50
MRF136	21.00	PT9847	21.00
MRF137	24.00	SD1278-1	17.75
MRF138	35.00	2N1522	11.95
MRF150	87.50	2N3553	2.25
MRF174	80.00	2N3771	3.50
MRF208	11.50	2N3866	1.25
MRF212	16.00	2N4048	11.95
MRF221	11.00	2N4427	1.25
MRF224	13.50	2N5109	1.75
MRF226	14.50	2N5179	1.00
MRF227	3.00	2N5589	7.25
MRF237	2.70	2N5590	10.00
MRF238	12.50	2N5591	13.50
MRF239	14.00	2N5641	9.50
MRF240	15.00	2N5642	13.75
MRF245	27.50	2N5643	15.00
MRF247	26.00	2N5945	10.00
MRF260	7.00	2N5946	12.00
MRF262	8.75	2N6080	6.25
MRF264	12.50	2N6081	8.00
MRF317	56.00	2N6082	9.50
MRF406	12.00	2N6083	9.75
MRF433	11.00	2N6084	11.50
MRF450	13.50	2SC730	1.25
MRF453	15.00	2SC1307	3.00
MRF458	20.00	2SC1946,A	15.00
MRF475	3.00	2SC1947	9.75
MRF476	2.75	2SC1969	3.00
MRF477	11.75	2SC2075	3.00
MRF479	10.00	2SC2097	28.00
MRF485	6.00	2SC2166	3.50
MRF485 MP KEN	18.00	2SC2312	4.95
MRF492A	18.75	2SC2509	9.00
MRF497	14.25	2SC2630	28.00
MRF515	2.50	2SC2640	15.00
MRF555	3.00	2SC2641	16.00
MRF607	2.50	3N204	2.00
MRF630	4.25	40582	7.50
MRF641	18.00	*OUTPUT MODULES*	
MRF644	21.00	SAU4 450 MHz	55.00
MRF646	25.00	SAU17A 903 MHz	50.00
MRF648	31.00	SAV6 150 MHz	42.50
MRF660	10.75	SAV7 146 MHz	42.50
MRF837	2.25	SAV15 222 MHz	48.00
MRF846	43.50	M57712, M57733	use
MRF901	1.25	M57737, SC1019	SAV7
MRF911	2.00	SC1027	use SAU4

Hi-Gain, Matched, and Selected Parts Available

We stock RF Power transistors for Atlas, KLM, Collins, Yaesu, Kenwood, Cubic, Mirage, Motorola, Heathkit, Regency, Johnson, Icom, Drake, TWC, Wilson, GE, etc. Cross-reference on CD, PT, SD, SRF, JO, and 2SC P Ns.

Quantity Pricing Available Foreign Orders Accepted

Shipping Handling USA $5.00 COD VISA MC

Orders received by 1 PM PST shipped UPS same day
Next day UPS delivery available

PARTS ORDERS ONLY — NO TECHNICAL
(800) 854-1927

ORDER LINE and or TECH HELP
(619) 744-0728
FAX 619-744-1943

RF PARTS
1320 Grand Avenue
San Marcos, CA 92069

the Quad antenna: part 2,
circular and octagonal loops

Analysis shows good performance with similar data

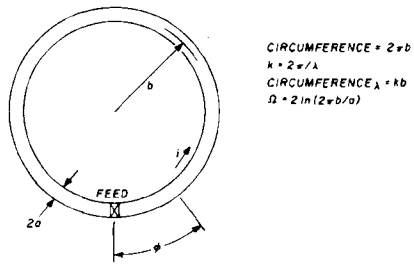


fig. 1. A circular loop can be described by two quantities, the radius of the conductor (a) and the radius of the loop (b). For work, it is convenient to use two derived quantities, a conductor thickness factor (omega) and the circumference in wavelengths at the operating frequency (kb).

Although there is a contradiction in terms, it is convenient to consider the circular loop, and arrays built of loops, as the first members of the Quad family. One reason is that all other versions can be regarded as departures from the "ideal" circular figure. To the extent this is true, the performance of circular-loop antennas is thus representative of the performance of the entire family.

Another reason is that the theoretical anaylsis of the circular loop is far more advanced than for the other shapes. Extensive tables of calculated characteristics have been published, some with comparisons of measured performance. In contrast, while there are theories of square Quad loop and array performance, their complexity makes them impractical for calculation, even on mainframe computers.

theoretical basis of circular-loop analysis

As shown in **fig. 1**, only two quantities are necessary to specify the circular-loop antenna: the conductor size, usually given as its radius; and the loop size, also described by radius. It is often more convenient to use two derived descriptive quantities in theoretical discussion. The first is the normalized circumference of the loop at the specific frequency of interest given by the quantity kb, where k is defined as

$k = 2\pi/\lambda,$

By R.P. Haviland, W4MB, 1035 Green Acres Circle North, Daytona Beach, Florida 32019

λ being the wavelength. The quantity kb is therefore the circumference of the loop in wavelengths. Conductor size is usually given by the relationship

$$\Omega = 2ln\left(\frac{2\pi b}{a}\right)$$

where ln is the natural logarithm, equal to 2.3 times the more common $\log_{10}$ value. The value of omega is given in **fig. 2** as a function of the ratio $2\pi b/a$, or loop circumference to conductor radius. Values less than 10 represent very large conductor diameters, and those over 20 very small conductors. High-frequency antennas will usually have values in the range 20-25, and self-supporting ultrahigh frequency antennas values of 10-15.

The loop is assumed to be fed at one point, usually taken as the angle reference. This induces a current, *i*, in the loop at angle zero which, in turn, creates a field at the point designated by R,01, for example. The total field at this point is the sum of the fields produced by all points on the loop.

The field components also induce current flow in the loop. When equilibrium is reached (after a few rf cycles) the field close to the conductor must lie only at right angles to it. (If there had been a tangential component, a change in the current would have been induced, so equilibrium would not yet have been attained.) This observation plus standard field equations give the conditions for calculating current distribution, and therefore the drive impedance and radiation pattern.

While the concept is relatively simple, the mathematical operations are difficult. See the references, especially Storer,[1] for details. For our purposes it is sufficient to note that the current distribution is given by:

$$I(\emptyset) = \frac{V}{(j \cdot \pi \cdot 377)}\left[\frac{1}{A_0} + 2 \cdot sum \frac{Cos\,(n \cdot \emptyset)}{A_n}\right]$$

where the sum is for all values of N from 1 to infinity. This result was derived by Hallen.[2]

This equation is simple, but its evaluation is complex. The quantities A involve series for which exact solutions are unknown. Even approximate solutions require further assumptions, two being that the conductor diameter is small compared to loop diameter and to operating wavelength. This restriction is satisfied by practical antennas.

Additionally, the infinite series in the equation tends

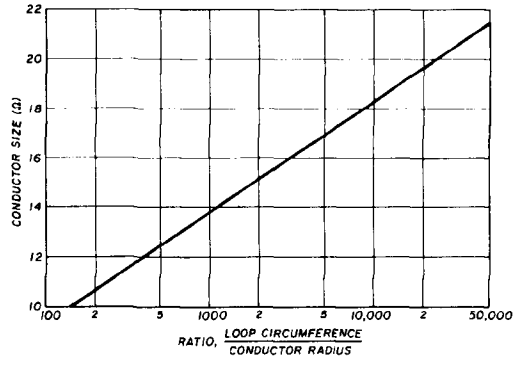


fig. 2. Values of the thickness factor (omega) as a function of the ratio of loop to conductor radius (or diameter). Practical self-supporting loops need an omega around 10-12 to have sufficient strength. Wire cage elements may be used to secure low omega factors at low frequencies.

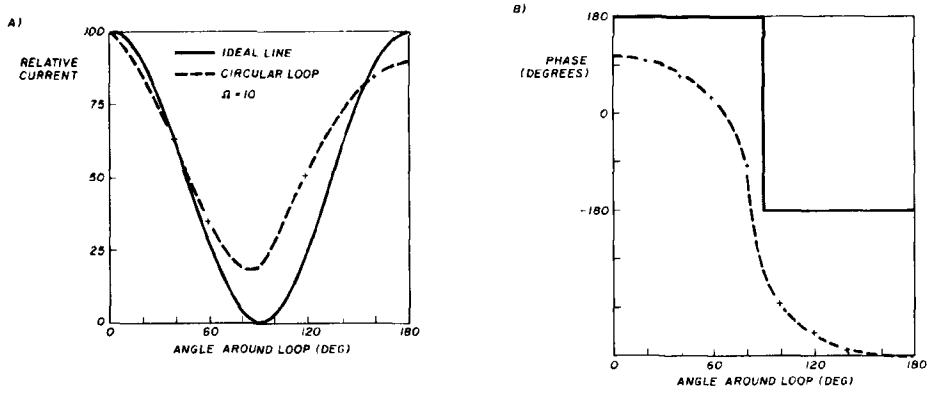


fig. 3. Current magnitude and phase on a large conductor circular loop one wavelength in circumference as derived by Storer.[3,1] The loop is below resonance. The current on a conductor of essentially 0 radius is shown for comparison. Derived from transmission line theory, this is the first approximation to the current on any loop of the same circumference.

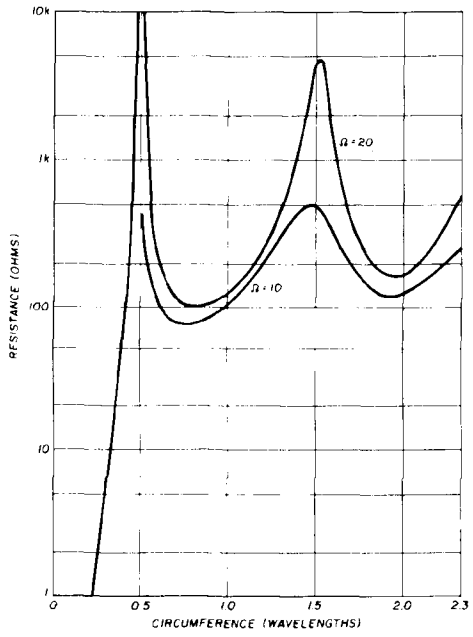


fig. 4A. Feedpoint or self-resistance of one-wavelength circumference loops — one with a large conductor radius, the other small. The drive resistance is sensitive to conductor size around the points of parallel resonance, at 0.5, 1.5, 2.5, etc. wavelengths circumference. These curves may be used as approximations for any loop of equal circumference and radius.

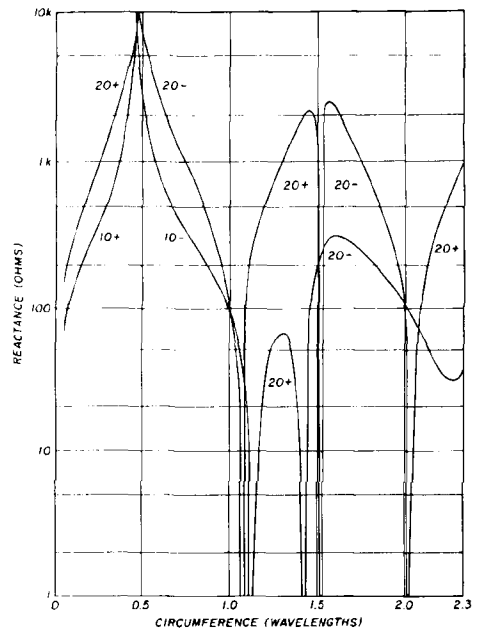


fig. 4B. Feedpoint or self-reactance of one-wavelength circumference loops. High reactance denotes the parallel resonances, low reactance the series resonances. Both series and parallel resonances are sensitive to conductor size. Series resonance is generally at wavelengths greater than integral values. Parallel resonances are at wavelengths less than odd multiples of 0.5 wavelength.

to become divergent when the number of terms is reduced for reasonable scale of calculation. Storer[3,1] developed a method of calculation by keeping the first four terms of the series and replacing the remainder by an integral. He also published a set of ten curves giving the real and imaginary components of the series. With these, evaluation of the current distribution and drive impedance is reduced to some simple (but tedious) curve measuring and complex-number algebra. Unfortunately, the curves cannot be reduced to simple equation form, so this can't be avoided.

Rather than presenting these curves and usage details here, I will give only the results of examination of some specific loop designs. Subsequent analyses have given a table of drive impedances, which is more accurate for most work. These values are covered later.

For values outside the range given here, or to obtain the current distribution, you will need the Storer curves. (The **reference 3** version is best, and is available at reasonable cost from Cruft Laboratory Library, Harvard University, Cambridge, Massachusetts.)

A simpler solution for small circular loops is available.[4] Here "small" covers the range from 0 to 0.3 wavelength circumference. This restriction allows

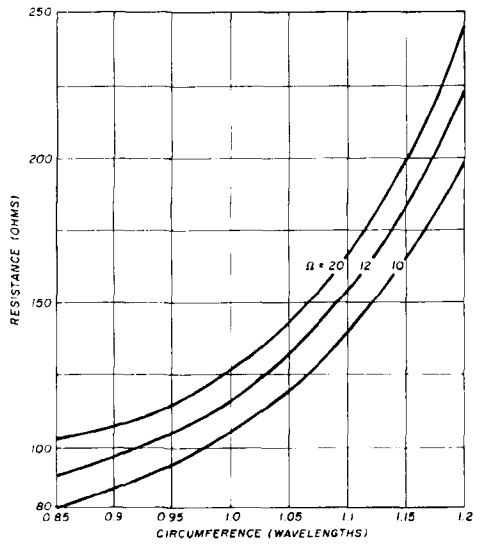


fig. 5A. Feedpoint or self-resistance of three loops around one-wavelength circumference.

simplification of the general equation above, with only three terms giving adequate accuracy. Approximate equations for each are given, and are easily handled by small computers. Note that the reactance for these small antennas is determined almost entirely by the loop circumference, with almost no effect on conductor size. In contrast, the input resistance varies with both.

current distribution on a circular loop

Figure 3 shows the magnitude of the current on a one-wavelength circular loop as calculated by Storer, together with the current magnitude on an ideal shorted transmission line made from one wavelength of conductor. **Figure 3B** shows the phase with respect to the driving voltage for both cases.

A number of important factors concerning the entire Quad family show on these curves. The first is that a one-wavelength loop is not resonant, as indicated by the fact that the angle of the drive impedance is not zero. Since the loop appears as a capacitance, it is below resonance. Unlike dipoles, loops must be longer than a wavelength to be resonant.

A second factor is that there is no point on the loop where the current goes to zero. Associated with this

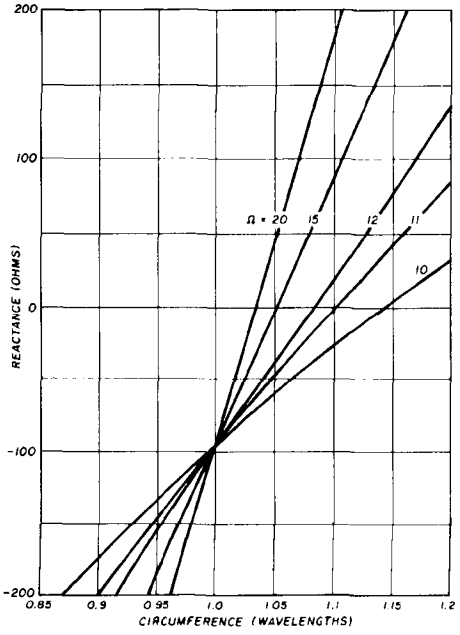


fig. 5B. Feedpoint or self-reactance of five loops around one-wavelength circumference. The reactance for all conductor sizes is equal to −95 ohms for a circumference of one wavelength. This may be compared with dipole reactance which shows the same characteristic, with a reactance of 35 ohms at 0.94 wavelength as the common point.

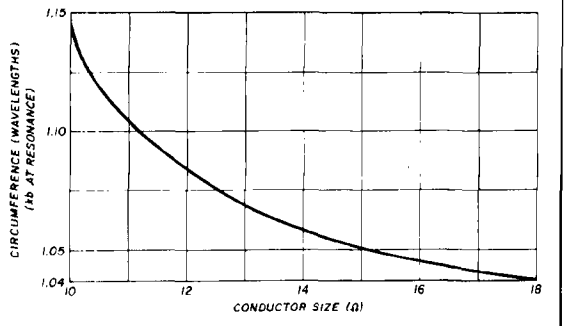


fig. 6. Resonant frequency of a circular loop derived from *fig. 5B*, as the frequency of 0 reactance. A simple linear relationship of reactance versus wavelength (or frequency) can be developed using two figures. However, the curves are usually less time consuming to use.

is the fact that the current at 180 degrees from the feedpoint is appreciably less than at the driving point. Similarly, these two currents are not 180 degrees out of phase, but somewhat more. The point of phase reversal is not at 90 degrees to the line of symmetry through the feedpoint.

One reason for the differences between the loop and the ideal shorted line is the greater separation of the sides. Currents are not constrained to be equal because of tight coupling, as in the ideal shorted line. Further, power is being radiated, causing a reduction in current when moving away from the feedpoint. (In a practical antenna, the current differences would be somewhat greater, as the analysis assumes zero ohms loss.)

These current curves show that the usual evaluation of a Quad — two separated dipoles with ends bent to touch — can't fully describe the performance. This simple concept is useful in verbal descriptions, and can be a valuable tool in approximate analysis. But it must be remembered that numerical results are probably in error by a factor *at least as large as the current error*, or at least 20 percent. The effect of the error should be smallest for pattern calculations and drive resistance, but is likely to be sizeable for drive reactance and resonant frequency.

These detail current calculations are for loops with relatively large conductors, $\Omega = 10$. Other studies, plus the tables presented later, show that the current magnitude and angle move progressively toward the curve for the ideal transmission line as the conductor radius becomes smaller. This means that the two-dipole approximation is likely to be better at high frequency than at ultrahigh frequency because omega is large for practical conductor sizes. The current distribution for some other loops is also given in **references 1, 3, 5,** and **6.**

As a first approximation, the current distribution can always be assumed to be that of an ideal transmission line of the same conductor length. A second approximation can be sketched by "rounding all sharp corners," and decreasing the current away from the feedpoint. Greater accuracy will require tedious evaluation using Storer's curves or the MININEC technique (to be discussed).

drive-point impedance

Get the drive-point impedance by dividing the drive-point voltage by the drive current calculated above. Storer[3,1] gives tables of this impedance for loops from 0.05 to 2.5 wavelengths in circumference, and for omega values from 8 to 12 (large diameter conductors).

In considering the general problem of loop antennas, Wu[7] developed another method for solving Hallen's equation. This gives the same values for resistance components as Storer, but the reactance values are quite different and agree more closely with measurements on real antennas. King, Harrison, and Tingley[8,9] have used Wu's theory to calculate loop-drive admittances for sizes from 0.05 to 2.5 wavelengths and for omega from 10 to 20. For those who have forgotten, or never had occasion to work with admittances,

$z = R + jX$

$y = 1/Z$

$y = g + jb$

(See also **reference 10.**)

Figures 4A and **4B** show feed resistance (R) and reactance (X), respectively, for loops from 0.05 to 2.5 wavelengths circumference. The two values of omega shown, 10 and 20, are representative of very high frequency and high-frequency loops.

Over this range of loop diameters, three high-impedance or parallel resonance points are noted, corresponding to 0.5, 1.5, and 2.5 wavelengths circumference. For $\Omega = 20$, the low-impedance, zero-reactance points correspond to serial resonances at about 1.0 and 2.0 wavelengths circumference. For $\Omega = 10$, there is also a serial resonance at 1.0 wavelength circumference. There is no true serial resonance for a circumference of 2.0 wavelengths. Instead, the reactance becomes low and remains low and capacitive. This is the case for all values of omega less than 11, and for all but the first serial resonance.

The resistance at the serial resonance point changes markedly with the value of omega. For omega that is large (20 or so), the resistance also varies markedly with loop diameter. But for $\Omega = 10$, the resistance change is much smaller. (For $\Omega = 8$, the change is less than 2:1 for any circumference greater than 0.6 wavelength.)

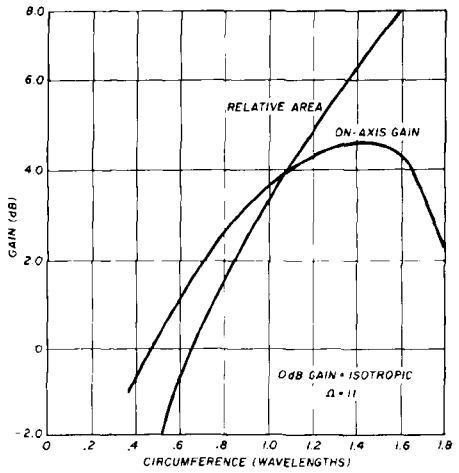


fig. 7. Gain of a circular loop in dB above isotropic, as derived by Ito et al.[11] Maximum gain occurs for a loop circumference of 1.4 wavelengths. Gain is less for smaller sizes due to less radiating area. On-axis gain, the value shown, is less at larger sizes because of lobe splitting. However, the gain of the main lobe increases as circumference increases. The associated curve shows the relative area of the loop.

These characteristics mean that thick loops are inherently broadband antennas and relatively easy to match. However, the pattern changes described in part 1 affect the desirability of this broadband operation, as discussed later.

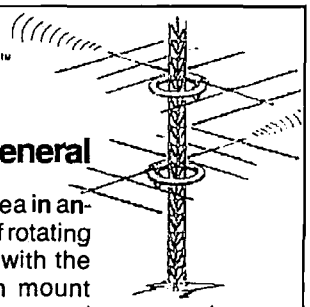
Figures 5A and **5B** show the feed resistance and reactance for frequencies of greatest interest (those close to the first series resonance) for loops from 0.8 to 1.2 wavelengths circumference. **Figure 6** is derived from **fig. 5B**, and shows the resonant frequency as a function of conductor size. These three curves give the information needed to design practical loop antennas and arrays and to calculate their performance. Their use is covered further on.

gain of loop antennas

In considering loop gain, it was noted that gain should increase as loop size increases and that there are pattern changes as size increases. Specifically, gain on the axis of symmetry becomes zero for all loops with 2, 3, or more wavelengths in conductor length.

These two effects are shown in the calculated gain curve of **fig. 7** (see **reference 11**). For a circumference of 1 wavelength, the on-axis gain is 3.4 dB above isotropic, or about 1.4 dB above a dipole. (Based on measurements, Lindsay[12] quotes approximately 4.0 dB, and Appel-Hansen[13] quotes 3.4 dB above isotropic.)

NETWORK SERIES 1000 ™
The Original Ringrotor



NEW FROM TIC General

Here's a fantastic new idea in antenna rotators? Instead of rotating one antenna per tower, with the Network 1000, you can mount several antennas on a tower and rotate each one either together in a phased array, or independently of each other.

Uses high strength steel gear drive, super strong I-beam ring construction and has been fully field tested. You can also aim the antenna to 1 degree of accuracy. TIC also has a digital control box available.

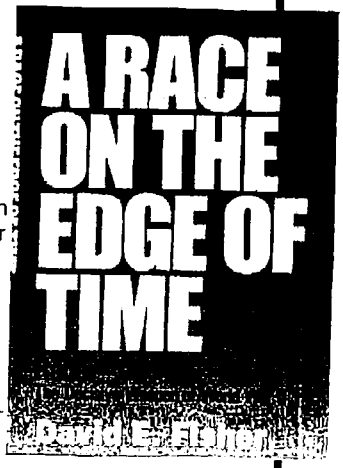
For more information about this exciting new antenna rotator, call TIC today.

(800) 423-6417 nationwide, **(800) 542-5009** MN or **(218) 681-1291 or write**
TIC General, P.O. Box 1
Thief River Falls, MN 56701.

Be the envy of your club when you demonstrate your new TIC Network 1000!

140

A RACE ON THE EDGE OF TIME
Radar — The Decisive Weapon of WW II
by David E. Fisher



A Race On The Edge Of Time reads like a thriller but is based upon painstaking and comprehensive research by the author. In fact, Fisher argues rather convincingly that radar was the crucial factor that allowed the allies to win the war and that radar has played the same important role in our current military and political environment. Filled with fascinating twists and turns of history that could have changed the war's outcome, anecdotes about the personalities involved in the development of radar and other military insights. Also includes radar development post WW II and how it will influence future battles. Illustrated with rare vintage photographs and diagrams.

☐**MH-21088** **Hardbound $19.95**

Please enclose $3.50 shipping and handling.

ham radio magazine **BOOKSTORE**
GREENVILLE, NH 03048 VISA **603-878-1441**

Figure 7 shows that larger loops are superior from the viewpoint of gain. A calculated gain value of 4.5 dB occurs for a loop circumference of 1.5 wavelengths. Above this circumference, the gain decreases, as the on-axis lobe splits. Remember, there is no radiation on axis for a circumference of 2 wavelengths.

In smaller sizes, the on-axis gain decreases as the circumference becomes less than a wavelength, and as the pattern changes toward the doughnut pattern of a small loop. The gain is about equal to that of a dipole at a circumference of about 0.65 wavelength, and about 1.5 dB poorer than that of a dipole for a circumference of 0.5 wavelength.

This brings up two important points. First, from the view of gain, the circular loop should be designed to operate away from resonance. Considering the factors of gain, lobe shape, and feed impedance, Ito et al.[11] recommend a design circumference of 1.2 wavelengths, for a gain of 4.2 dB.

Second, a loop has good gain performance over a wide range of frequences. For example, a 14-MHz loop would be slightly better than a dipole on 10 MHz, and about 1.5 dB poorer on 7 MHz. The gain would be near maximum on 21 MHz, better than a dipole on 18 MHz, and about as good on 24 MHz. The on-axis gain would be poor on 28 MHz, but there would be usable radiation in two lobes.

The acceptability of operation away from resonance is affected by the difficulty encountered in feeding the loop. From **fig. 4**, feeding a large loop on high frequency does not appear to be an unusual problem. The feed resistance would increase, but a matching section or transformer is needed. There would be an inductive component, easily compensated by a stub. Depending on conductor size, a very high frequency loop might require only a matching transformer.

Wideband operation would be a greater problem.

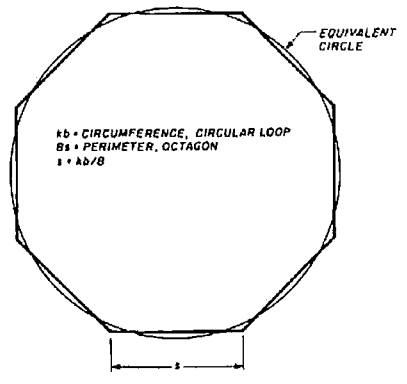
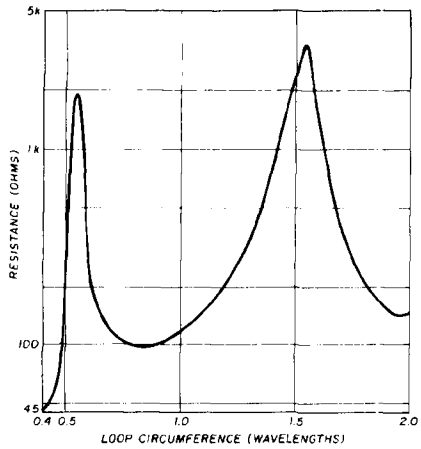


fig. 8. Relative geometry of a circle and an octagon. The difference in area for the same conductor length is very small.



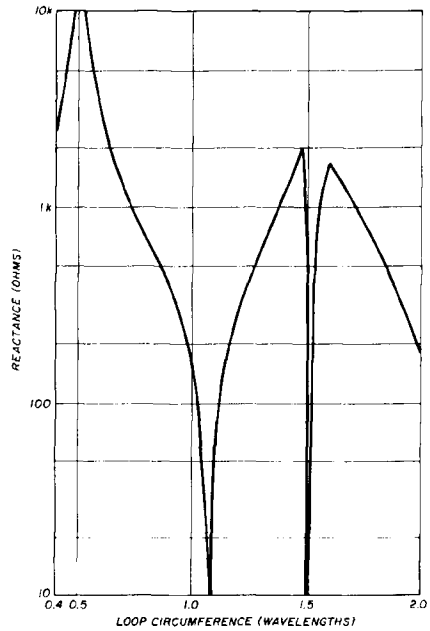


fig. 9. (A) Feed or self-resistance of an octagonal loop for Ω = 17.9, calculated by MININEC 3.[14] Values are within a few percent of those for the corresponding circular loop. (B) Feed or self-reactance of an octagonal loop. Differences between these and circular loop values are somewhat geater than for resistance. They are due to different area, and the geometry of current interaction. It is likely that there are also differences due to the calculation approximations, since the expected calculation error may reach 10 percent.

You'd need a complex matching section at the antenna, or your transmission line would have appreciable VSWR. The combination of open-wire line and a wide-range "Match Box" would give excellent performance. This is especially interesting as the basis of a 3.5/7/10-MHz fixed-loop design.

I have made use of this wideband capability on many occasions. A 14-MHz loop is regularly used on bands from 7 to 28 MHz. Much of my 10, 18, and 24-MHz experimental work (KK2XJM) used this antenna. Other than Teflon™ insulated 75-ohm feedline and a pi-section tuner, no special precautions were taken.

circular-loop radiation patterns

Published data on radiation patterns of loop antennas varies from sparse to nonexistent. The equations needed to calculate the currents and patterns are solvable on a small computer only with a lot of programming and computing time. It has been necessary to approximate further to develop the pattern data which follows.

the MININEC antenna program

The chosen calculation technique (sometimes called "the method of moments") is the public domain program "MININEC," from Logan and Rockway,[14] currently in its third version. It uses essentially the same initial assumptions as the Hallen[2] approach above. But instead of applying the geometry exactly and then making simplifying assumptions, assume that the radiator is composed of a series of straight-line sections carrying constant current.

A solution's accuracy increases as the number of sections for a given geometry is increased. While the complexity of the solution is not greatly affected, the time required for the solution increases as the square of the number of segments. An IBM PC may take several hours to run the program; a very small computer like the Commodore 64 may need 12 to 24. Even so, this approach is the best generally available, and is quite practical.

The original MININEC[15] was written for the Apple computer. I have translated it for the C-64 and the Amiga; KA4WDK has done the same for the PC. The third version was written for the PC, and I translated it for the Amiga; it also runs on the Macintosh.

MININEC originators used various conditions to examine calculation accuracy, including analysis of loops. One series used a ten-sided polygon approximation of a circle, with two current segments per side plus three for the feed side. Agreement with theory was to within 10 percent.

A second series approximated the circle using the circumscribed polygon. This shows good agreement ($\pm$6 percent) for susceptance, down to four sides. Equally good agreement for conductance required 16 sides. With 22 sides, agreement was within 6 percent for sizes from 0.1 to 2.0 wavelengths. MININEC solu-

tions are found to be unreliable for circumferences less than about 0.01 wavelength.

The inscribed polygon approximation is not an ideal check of solution accuracy as the number of segments decreases. It introduces two added factors which change the results. One is the loss of area. (For eight sides this amounts to about 3 percent.) This reduces the gain by about the same amount. More important, the total conductor length decreases as the number of segments decreases, by about the same percentage. This change in wire length introduces a change in reactance near the series-resonant points, and a change in resistance near parallel-resonant points. Both may be relatively large.

A better approximation occurs when the conductor length is kept constant. It is not easy to evaluate the precise error this causes, but it appears that it is no greater than the sum of the inherent error of MININEC plus the area error in the approximation.

It also appears that the inherent error will be around 5 to 10 percent if two simple rules are followed in setting up a MININEC analysis:

- use a minimum of two segments per section of conductor,
- use a minimum of four segments per halfwave of conductor.

Practically, MININEC gives extremely good accuracy. An antenna can easily depart from its ideal value by 20 percent or more because of neglected factors like supports, tower location, and feed-antenna interaction.

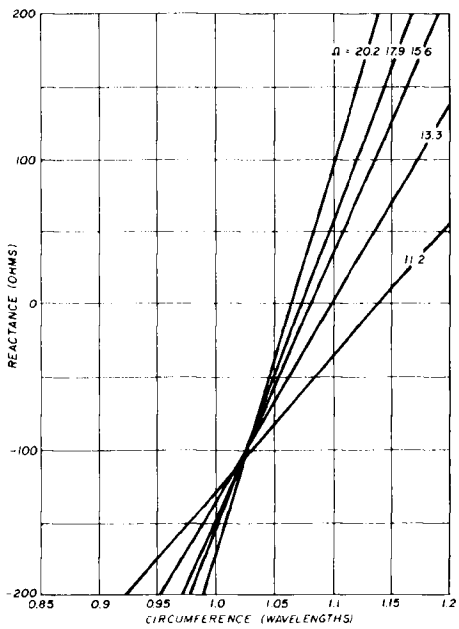


fig. 10. Feed or self-reactance of an octagon for circumferences around one wavelength. The point of equal values occurs at the same reactance as the circular loop but at a greater circumference. Curve slopes are almost identical.

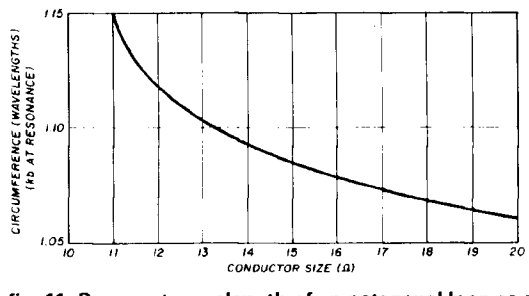


fig. 11. Resonant wavelength of an octagonal loop as a function of conductor thickness. The curve is similar to that of a circular loop, but differs by as much as ±6 percent.

octagonal loop

Calculated values for an octagonal loop should be a good approximation of circular-loop values. The octagon is also a useful antenna by itself. Probably the best-known type is the "Army Loop" — really a loop operating well below resonance, incorporating both a matching system and low-loss construction. **Figure 8** shows the basic factors involved, and allows visualization of the small area difference from the circular loop.

The properties of the octagon for conductor lengths close to 1 wavelength are summarized by **figs. 9A** and **9B** for drive resistance and reactance. These should be compared with **figs. 4A** and **4B** to see the validity of the octagon approximation to a circular loop. As expected from previous discussions, the agreement

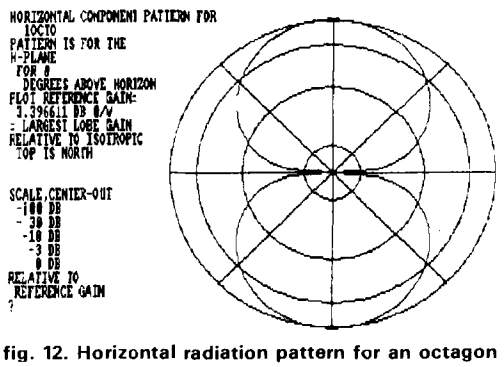
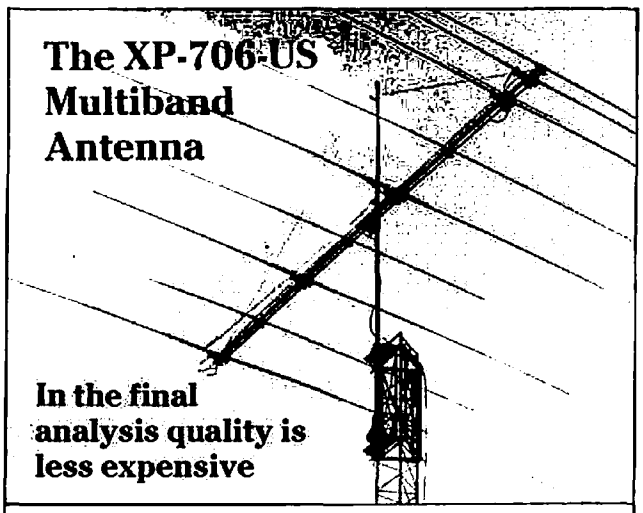


fig. 12. Horizontal radiation pattern for an octagon lying in a vertical plane and fed at the bottom. Only the horizontally polarized component is shown. The pattern is very similar to that of a dipole, but the gain is higher by about 1.25 dB.



The XP-706-US Multiband Antenna

In the final analysis quality is less expensive

The unique design of the XP-706-US antenna system gives you MONOBAND PERFORMANCE in a Multiband beam. The antenna *USES NO TRAPS* of loading coils that rob power and limit bandwidth. Sommer Antennas use the FULL surface area of the elements on ALL bands.

Our commitment to use only the finest materials insures that your investment will last for years. Our system uses a Double rectangular boom, CAST aluminum element mounting brackets, all stainless hardware and a high power balun

Monoband performance on a *Multiband* beam is yours when you move up to Sommer the last beam you'll have to buy. We believe Sommer is your best antenna value when compared to the construction and performance of other multi and monoband antenna systems.

H.J. Theiler Corp.
P.O. Box 5369
Spartanburg, SC 29304
(803) 576-5566

SOMMER

130

INTERNATIONAL MONTHLY MAGAZINE BY AND FOR ACTIVE RADIOAMATEURS

Radiosporting

THIS IS IT! - FOR BIG GUNS & LITTLE PISTOLS

A magazine dedicated to quality and sportsmanship in amateur radio operating. Fresh, timely, practical and down to earth reading for little pistols and big guns. Written by the world's best in their fields: ON4UN, SMØAGD, LZ2CJ, VE3BMV, KH6BZF, DJ9ZB, ZS6BRZ, W1WY, N2SS, K7GCO, K4ZN, W4GF, VE3JTQ, WB4ZNH, WB9TBU, KQ2M, NS6X, W2XQ, W3FG, KA3B, K1PLR, N3IK, N7CKD, VE3XN, ABØX, JE1CKA and others.

Includes DX News, QSL Info, 160m, 80m, 10m, 6m columns, DXpeditioning, Propagation, Awards, Contest Rules and Results, Traffic - Emergency, FCC News, New Products, Antennas, Technical News and articles, Equipment Reviews and Modifications, Computer Programs, Radio Funnies, Club Life, SWL, RTTY, VHF/UHF, Mail Box, Classified Ads and much more in a magazine format with the speed of a bulletin. RADIOSPORTING sponsors DX Centurion Award, Contest Hall of Fame and World Radio Championship contest.

"Your publication is superb! Keep it up!" Joe Reisert, W1JR

"Your W2PV articles are priceless. Your magazine is super!" Rush Drake, W7RM

"Let me congratulate you on a very impressive magazine. Just what I've been looking for as a DXer and Contester!" Dick Moen, N7RO

"RADIOSPORTING, once received, cannot be tossed aside until it is read from cover to cover. Then reviewed again and again." Chas Browning, W4PKA

"I take every ham magazine and can say without reservation that RADIOSPORTING is the first one read each month." Joe Rudi, NK7U, "Oakland A's"

Subscription rates: 1 year USA $18, Canada CDN$28, Overseas US$25; 2 years $33, $50, $44 respectively. Single issue $2.

USA First Class Mail add $10/year, DX Air Mail add $20/year.

TRY US! SUBSCRIBE OR SEND $1 FOR YOUR SAMPLE COPY. *VISA, MASTERCARD accepted.*

RADIOSPORTING Magazine
PO Box 282, Pine Brook, NJ 07058, USA Tel. (201) 227-0712

131

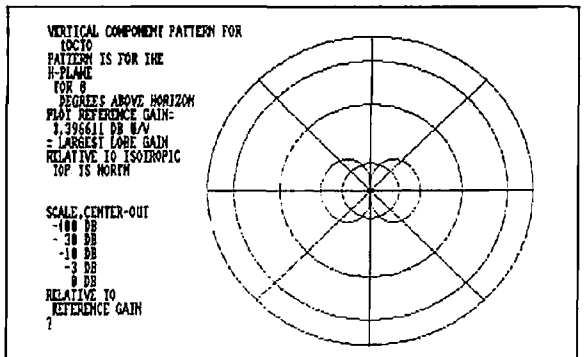


fig. 13. Vertical radiation pattern for the total radiation from an octagon in the plane of the loop. Maxima are along the line of maximum current. The minima represent the expected side radiation. (kb = 1.0, Ω = 17.9)

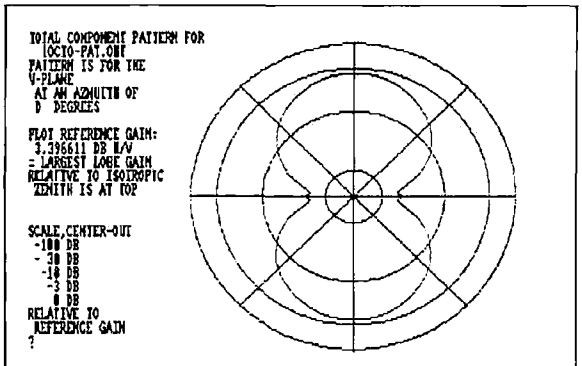


fig. 14. Horizontal radiation pattern for the vertically polarized component of an octagon lying in a vertical plane and fed at the bottom. This component is about 20 dB below the main lobe because of the currents on the vertical and inclined parts of the octagon.

for resistance is good — no more than a few percent difference. The agreement for reactance is not quite as good; this is the usual finding. However, neither error is beyond the expected range.

If you build a practical octagon antenna, use **figs. 10** and **11** if the antenna is to be resonant or nearly so. If it is away from resonance, the values from **table 1** give a good approximation. For best accuracy, the table values should be interpolated for the actual conductor diameter and equivalent radius. Alternatively, MININEC can be used to obtain values within 5 to 10 percent error.

patterns of circular/octagonal loops

Because the octagon has been found to be a good approximation to the circle, we can use its pattern as a close approximation to those of circular loops.

Figure **12** shows the MININEC calculated horizontal plane pattern for a 1-wavelength octagon fed at

the center of the bottom segment — that is, with horizontal polarization. The lobes are very nearly the same as those of a dipole, but are slightly narrower to produce gain. The gain is 3.4 dB, essentially that of a circular Quad.

Figure 13 shows the vertical plane pattern in the plane of the loop, for the total radiation. **Figure 14** shows the horizontal plane pattern for vertical polarization. There is a major difference from dipole patterns in these two figures. The loop has an appreciable vertically polarized component, zero on axis and maximum at right angles to this. This component is not present with dipoles and its importance is not clear. It may have an adverse effect because of interference received on the vertically polarized side lobes (and back lobe in beams), or it may tend to reduce fading due to variation of incoming signals and path splitting. The component may also be a factor in the reputation of Quad loops as good performers at low height. More aspects of these questions will be discussed in other parts of this series.

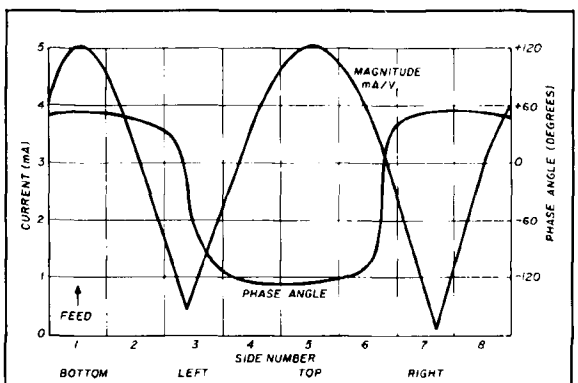


fig. 15. Current distribution on an octagon. Because of the small conductor size, the distribution approaches that of an ideal transmission line.

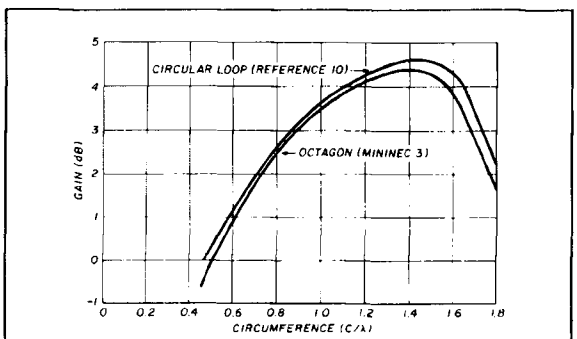


fig. 16. Calculated gain of a circular loop and an octagon. The difference is small — partly real and partly due to differences in the calculation technique. The curves do confirm the extra gain of a loop as compared with a dipole, and also indicate the added gain possible with off-resonance operation.

Figure 15, provided for comparison, shows the calculated current on an octagon. Because the example is for a relatively thin conductor, there is close resemblance to the distribution for a transmission line.

Figure 16 compares the calculated gain of an octagon and a circular loop. Some of the variation is due to the difference in areas. The rest appears to be related to differences in the calculation method. Practically, the difference is negligible.

General conclusions from this comparison of circular and octagonal loops are that both have good performance, and that the data from one can be used for the other with little error.

We will use this last finding in part 3, which is devoted to arrays composed of circular and octagonal loops. Design data for arrays of two to twelve elements will be given.

references

1. Storer, "Impedance of Thin-Wire Loop Antennas," Transactions of AIEE Communications, November 1956.
2. Hallen, "Theoretical Investigations Into Transmitting and Receiving Qualities of Antennae," Nova Acta Regiae So. Sci., Upsaliensis (Sweden), (4) 11 1938.
3. Storer, "Impedance of Thin Wire Loop Antennas," Cruft Laboratory Technical Report 212, May 1955.
4. C.L. Chen and R.W.P. King, "The Small Bare Loop in an Infinite Conducting Medium," IEEE Transactions Antennae Propagation, May 1963.
5. Phyllis A. Kennedy, "Loop Antenna Measurements," IRE Transactions, Antenna Propagation, October 1956.
6. R.W.P. King and C.W. Harrison and D.G. Tingley, "The Current in Bare Circular Loop Antennas in a Dissipative Medium," IEEE Transactions Antenna Propagation, July 1965.
7. Wu, "Theory of Thin Circular Loop Antenna," Journal of Mathematics and Physics, 3, November, December 1962.
8. R.W.P. King, C.W. Harrison, and D.G. Tingley, "The Admittance of Bare Circular Loop Antennas in a Dissipative Medium," Cruft Laboratory Technical Report no. 419, August 1963.
9. R.W.P. King, C.W. Harrison, and D.G. Tingley, "The Admittance of Bare Circular loops in a Dissipative Medium," IEEE Transactions Antenna Propagation, July 1964.
10. R.W.P. King and C.W. Harrison, "The Admittance of Bare Circular Loop Antennas in a Dissipative Medium, Sandia Corporation Monograph SCR 674, 1974.
11. Shin'ichi Ito, Naoki Inagaki, and Toshio Sekiguchi, "An Investigation of the Array of Circular-Loop Antennas," IEEE Transactions Antenna Propagation, July 1971.
12. James E. Lindsey, Jr., "A Parasitic End-fire Array of Circular Loop Elements," IEEE Transactions Antenna Propagation, September 1967.
13. J. Appel-Hansen, "The Loop Antenna with Director Arrays of Loops and Rods," IEEE Transactions Antenna Propagation, July 1972.
14. J.C. Logan and J.W. Rockway, "The New MININEC (Version 3): A Mini numerical Electromagnetics Code," Naval Ocean System Center TD 938, September 1986.
15. A.J. Julian, J.C. Logan and J.W. Rockway, "MININEC: a Mini-numerical Electromagnetics Code," Naval Oceans System Center TD 516, September 1982.

ham radio

PART 3 — COMING UP IN OUR JULY ISSUE.



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

a nifty bi-square beam for 10 or 12 meters

The miserable DX conditions at the bottom of the sunspot cycle are but a bad memory. True, the higher frequency bands tend to fizzle during the summer, but they'll be back again with a bang as soon as the cooler fall months roll around.

If you're interested in DX operation on either 10 or 12 meters, you'll eventually need a beam antenna. You can work a lot of "easy" DX with a dipole, but sooner or later you'll wish you had a beam for the more exotic DX stations. An easy solution is to buy a Yagi beam kit, but it's less expensive to build your own wire beam from scratch. Here's an inexpensive beam for your consideration.

The Bi-square beam (**fig. 1A**) is a derivation of the so-called "Lazy-H" array, a favorite of point-to-point stations in the maritime and fixed services. The Lazy-H consists of two half-wave dipoles in phase over a similar pair of dipoles. Spacing between the top and bottom dipole pairs is a half wavelength. Proper phasing of the pairs is achieved with a transposed open-wire transmission line fed at the center of the lower pair of dipoles with a quarter-wave, open-wire stub. The feedpoint impedance at the bottom of the stub is about 220 ohms.

A more practical version of the Lazy-H antenna is the Bi-square beam, shown in **fig. 1B**. This arrangement requires only a single center pole support. The Lazy-H dipole pairs are connected together at the outer tips, resulting in a diamond-shaped wire arrangement. You can eliminate the transposed line connecting the center of the pairs. The quarter-wave stub is retained.

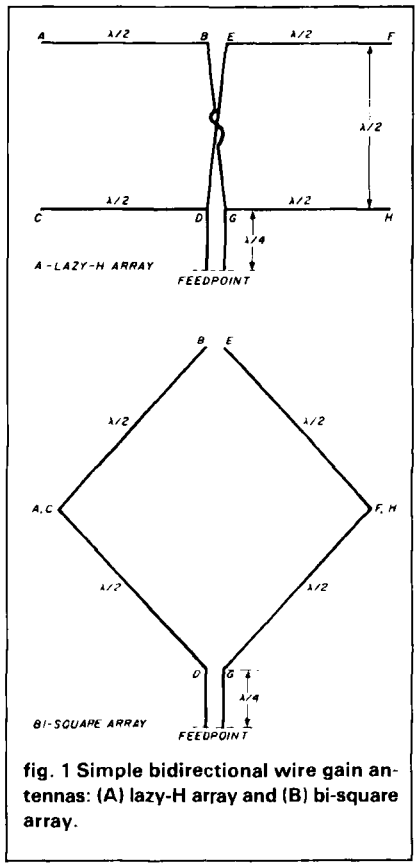


fig. 1 Simple bidirectional wire gain antennas: (A) lazy-H array and (B) bi-square array.

The feedpoint impedance at the bottom of the stub is close to 150 ohms. There is a reduction in feedpoint impedance because the top and bottom radiating elements of the Bi-square configuration are closer to each other than they are in the Lazy-H antenna.

The Bi-square radiation pattern is a figure eight (bidirectional) at right angles to the plane of the array. The power gain over a dipole located at the center height of the array is about 5 dB.

building the bi-square beam

The Bi-square is an easy, inexpensive beam to build. You'll need about 100 feet of No. 16 enamel or Formvar™ coated wire and four insulators. The quarter-wave stub needs five spreaders cut from 1/2-inch diameter phenolic (or plastic) rod. One of the spreaders serves as the bottom insulator for the antenna wires. The diamond-shaped

antenna is open at the top (two insulators required). Overall height is a little less than 30 feet. I hung mine from a yard arm at the 45-foot level of my crank-up tower. The proximity of the metal tower to the plane of the loop didn't seem to cause any harm.

Dimensions for the 10- and 12-meter versions of the antenna are given in **fig. 2**. The sides are pulled out by ropes and tied off to convenient points on nearby trees. The bottom of the quarter-wave stub is about 7 feet above the ground.

The yard arm holds the loop about 3 feet away from the tower. The loop isn't quite in the vertical plane because I pulled the bottom of it 6 feet away from the tower in order to reach the bottom of the stub easily from the garage roof.

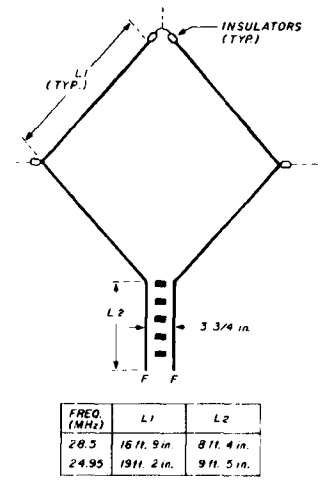
The Bi-square antenna's bandwidth is very broad; the antenna may be cut to the dimensions given without further ado. Purists may wish to trim the antenna to a specific frequency in the 10-meter band. Design frequencies for the antenna shown are 28.5 and 24.95 MHz. The 10-meter antenna covers the whole band with an SWR of less than 1.5:1 — quite an achievement!

adjusting the antenna to frequency

It's easy to set the resonant frequency of the antenna "on the nose." The bottom of the stub (F-F) is shorted by a jumper that has a one-turn loop in the center. The loop is just big enough to fit over the coil of a dip oscillator. My shorting bar is made of two interconnected copper alligator clips so I can move it up and down the stub for adjustment. The dip oscillator is monitored in a nearby receiver. Move the shorting bar up and down the stub, an inch or so at a time, until the resonant frequency falls where you want it. Finally, cut the stub to the determined length.

matching antenna to feedline

As I stated earlier, the feedpoint impedance of the antenna is about 150 ohms. The antenna is symmetrical



FREQ. (MHz)	L1	L2
28.5	16 ft. 9 in.	8 ft. 4 in.
24.95	19 ft. 2 in.	9 ft. 5 in.

fig. 2. Bi-square antenna dimensions for 10- and 12-meter bands feedpoint impedance is about 150 ohms.

with respect to ground, and the feedpoint is balanced to ground. Two transformations are required to match the antenna to a 50-ohm unbalanced (coaxial) line. The 50-ohm point is first transformed from unbalanced to balanced by a 1:1 balun. The 50-ohm balanced condition is then transformed to 150 ohms. The first transformation is easy; I use a "Bencher ZA-1A" air-core balun which provides an excellent balance in the 10-meter region.

The transformation from 50 ohms to 150 ohms can be done in a number of ways. One is to use a ferrite toroid transformer (**fig. 3**). Take a core 2.4 inches in outer diameter and 0.5 inch high (Amidon FT-240-67, or equivalent) with a permeability of 40. Sand it to remove rough edges, and then wrap it with a layer of electrical vinyl tape. Wind 18 turns of No. 14 enamel

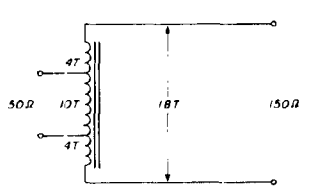


fig. 3. A 1:3 balanced transformer wound on ferrite toroid (Amidon FT-240-67).

wire around the core, tapped four turns from each end. Space the winding around the entire core. Fasten the completed transformer to a phenolic mounting plate with epoxy cement, and mount the assembly in a waterproof box for protection from the weather.

a linear matching transformer

The second matching scheme uses a linear transformer, (**fig. 4**). The design is based on a balanced L-network. The circuit (**fig. 4A**) was built using a receiving-type variable capacitor for initial tests. The dimensions shown allow adjustment of the capacitor which quickly drops the SWR on the transmission line to unity at the design frequency of the antenna. The last step is to replace the variable capacitor with a fixed one and substitute a section of transmission line for the network inductors (**fig. 4B**). This works like a charm. A 50-μF, 5-kV ceramic capacitor (Centralab 850S-50Z, or equivalent) is substituted for the variable unit. Place it in a plastic refrigerator jar to keep moisture away. The short line section is made up in the same manner as the quarter-wave stub.

results

For a few days the dipole was left in position as a comparison with the Bi-square. In all tests, the Bi-square outperformed the dipole (usually between one and two S-units on transmit). On receive, signals that were almost in the noise were perfectly readable on the Bi-square antenna. No doubt about it, the Bi-square delivers the goods!

a 15-meter version?

The Bi-square should work well on 15 meters if you have the space. Multiply all 10-meter linear dimensions by 1.34 to get antenna size for this band.

W5LDA 160-meter antenna

Jim, W5LDA, has an interesting 160-meter antenna that incorporates a simplified feed system (**fig. 5**). He uses

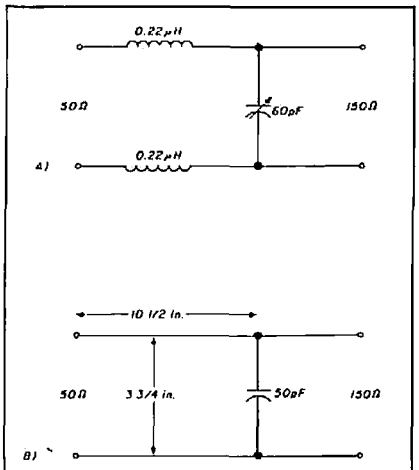


fig. 4. Linear matching transformers. (A) L-network uses lumped L and variable C (five turns, 1/2-inch I.D., No. 14 wire, eight turns per inch). (B) Linear network transformer made of No. 16 wire. Ends of wire are bent in 1 inch to connect to balun.

his 54-foot tower (with a triband Yagi atop it) as a vertical, top-loaded radiator. Rather than fooling around with a gamma match on the tower (which can prove to be very tricky), Jim made his tower into a voltage-fed unipole antenna. He fastened a wire to the top, brought it off at an angle, and voltage led the bottom end. The natural resonance of the top-loaded tower is such that only a simple matching network is required.

The base of the tower, as well as the shield of the coax running to the beam, are grounded at the tower base. Each lead of the rotor cable (not shown) is bypassed to ground at the tower base with a 0.01-μF, 1.6-kV disc capacitor. The leads are also bypassed to the tower at the rotor. (Jim learned the hard way that bypassing is important, after he burned out the rotor potentiometer atop the tower running 1500 watts on 160 meters!)

The coax and rotor cables are buried in a hose and run to the shack. Twenty radials, each 65 feet long, are fanned out on the surface of the ground beneath the tower.

The end of the wire is at a high voltage point and is brought into the station via a ceramic feedthrough insulator. A simple L-network matches the antenna to 50-ohm coax running to the operating position.

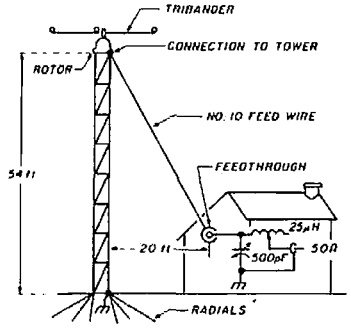
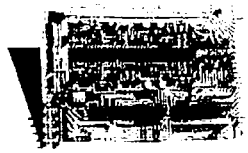


fig. 5. 160-meter folded unipole antenna at W5LDA. Rotor cable and coax for beam is strapped to tower leg.

The antenna is very high-Q (narrow bandwidth); the network must be readjusted for a frequency change. It is possible to achieve 80-meter operation of the antenna by retuning the network.

ham radio

THE MULTIPLE RECEIVER SOLUTION



4 Channel Signal-to-Noise Voter

- Expandable to 32 Channel by Just Adding Cards
- Continuous Voting
- LED Indicators of COR and Voted Signals
- Built-in Calibrator
- Remote Voted Indicators Pinned Out
- 4½ x 6 Double Sided Gold Plated 44 Pin Card
- Remote Disable Inputs
- MORE

Built, tested and calibrated with manual

$350.00

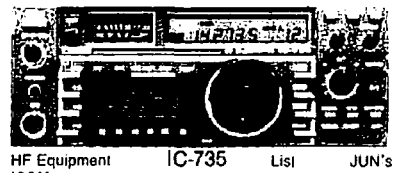
Telephone interface now available
For more information call or write:

DOUG HALL ELECTRONICS
Voter Department
815 E. Hudson Street
Columbus, Ohio 43211
(614) 261-8871

↙ 129

800-882-1343

ICOM



HF Equipment IC-735	List	JUN's
ICOM		
IC-781 New Deluxe HF Rig	$5995	Call $
IC-761 Loaded with Extras	2699	Call $
IC-735 Gen. Cvg Xcvr	1099	Call $
IC-751A Gen. Cvg Xcvr	1699	Call $
Receivers		
IC-R7000 25-1300¹ MHz Rcvr	1199	Call $
IC-R71A 100 kHz-30 MHz Rcvr	999	Call $
VHF		
IC-28A/H FM Mobile 25w/45w	469/499	Call $
IC-02AT FM HT	409.95	Call $
IC-u2AT Micro HT	329	Call $
IC-900 Six Band Mobile	639	Call $
UHF		
IC-48A FM Mobile 25w	509	Call $
IC-04AT FM HT	449	Call $
IC-12AT 1.2 GHZ HT	473	Call $
220 MHz		
IC-38A 25w FM Xcvr	489	Call $
IC-37A FM Mobile 25w	499	Call $

KENWOOD

KENWOOD		
HF Equipment		
TS-940S/AT Gen. Cvg Xcvr	2449.95	Call $
TS-440S/AT Gen. Cvg Xcvr	1379.95	Call $
TS-140S Compact Gen. Cvg Xcvr	929.95	Call $
VHF		
TS-711A All Mode Base 25w	1029.95	Call $
TR-751A All Mode Mobile 25w	649.95	Call $
TM-2530A FM Mobile 25w	479.95	Call $
TM-2550A FM Mobile 45w	499.95	Call $
TM-2570A FM Mobile 70w	599.95	Call $
TH-215A 2m HT Has II All	379.95	Call $
TH-25AT 5w Pocket HT NEW	349.95	Call $
TM-721A 2m/70cm FM Mobile	649.95	Call $
UHF		
TH-415A 2.5w 440 HT	399.95	Call $
TH-45AT 5w Pocket HT NEW	369.95	Call $
220 MHz		
TM-3530A FM 220 MHz 25w	499.95	Call $
TH-31BT FM 220 MHz HT	299.95	Call $
TH-315A Full Featured 2.5w HT	399.95	Call $

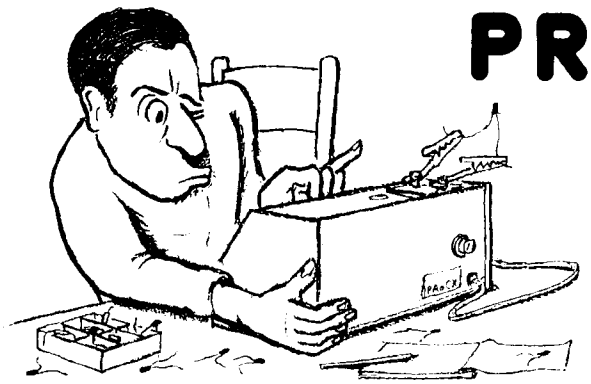
YAESU

YAESU		
HF Equipment		
FT-767 GX Gen. Cvg Xcvr	1929.95	Call $
FT-757 GX II Gen. Cvg Xcvr	1129.95	Call $
FT-747 GX New Economical Performer	889.95	Call $
FL-7000 15m-160m AMP	1995.00	Call $
VHF		
FT-212RH NEW 2m 45w	459.95	Call $
FT-211RH FM Mobile 45w	389.95	Call $
FT-712RH 70cm 35W	499.95	Call $
FT-290R All Mode Portable	599.95	Call $
FT-23 R/TT Mini HT	344.95	Call $
FT-209RH FM Handheld 5w	389.95	Call $
VHF/UHF Full Duplex		
FT-736R, New All Mode 2m/70cm	1749.95	Call $
Dual Bander		
FT-727R 2m/70cm HT	439.95	Call $
FT-109RH New HT	399.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

↙ 128



PRACTICALLY SPEAKING

Joe Carr, K4IPV

"ferriting" out the problem

Ferrite refers to materials that behave similarly to powdered iron compounds. They are used in radio equipment as inductors and transformers. Although they were made originally from powdered iron (and indeed the name *"ferrite"* still implies iron), many modern materials are made of other compounds. According to the Amidon Associates, ferrites with a permeability of 800 to 5000 have manganese-zinc composition, while cores with permeabilities of 20 to 800 are of nickel-zinc.[1] The latter are useful in the 0.5- to 100-MHz frequency range of interest to most Amateurs.

toroidal cores

This month's column will answer your questions about ferrite cores, winding toroidal cores, and using ferrite inductor and transformer cores.

A toroid is a "doughnut" shaped object, so a toroidal core is an inductor or transformer form made of a ferrite material in the shape of a doughnut. Core nomenclature provides useful information about shape, size, and type of material. For example the number *FT—xx—nn* means a ferrite toroid (FT) with an "xx" size, and an "nn" material type. The "F" in "FT" is sometimes deleted on parts lists, and the core defined as a "T-xx-nn."

Amidon has a chart that provides dimensions, a description of the properties of the different types of material, and other physical data. Some of these data are also found in *The 1988 ARRL Handbook for the Radio Amateur*[2], beginning on page 2-32 (the same material appeared in earlier editions as well).

Tables 1 and **2** are derived in part from both Amidon and ARRL sources; **table 1** shows the sizes and **table 2** the properties of various popular toroids. These tables do not contain an exhaustive list of the variety of toroids available or all the properties of the toroids mentioned. Using the nomenclature mentioned above and the tables, you can see that a T-50-2 core (which might be called for in the parts list of a *ham radio* article) refers to a core that is useful from 1 to 30 MHz. It has a permeability of 10, is painted red, and has the following dimensions: OD = 0.500 inches, ID = 0.281 inches, and height (i.e. thickness) = 0.188 inches.

Table 1. Standard Toroid Core Sizes ("xx")

Core size	OD (inches)	ID (inches)	Thickness (inches)
23	0.230	0.120	0.060
37	0.375	0.187	0.125
50	0.500	0.281	0.188
50A	0.500	0.312	0.250
50B	0.500	0.312	0.500
82	0.825	0.520	0.250
87A	0.870	0.540	0.500
114	1.142	0.750	0.295
114A	1.142	0.750	0.545
130	1.300	0.780	0.437
150	1.500	0.750	0.250
150A	1.500	0.750	0.500
193	1.930	1.250	0.750
200	2.000	1.250	0.550
240	2.400	1.400	0.500

Table 2. Properties of Core Types

Material type	Color code	μ	Frequency (MHz)
41	Green	75	
3	Grey	35	0.05—0.5
15	Red/ White	25	0.1—2
1	Blue	20	0.5—5
2	Red	10	1—30
6	Yellow	8	10—90
10	Black	6	60—150
12	Green/ White	3	100—200
0	Tan	1	150—300

toroidal transformers

One reader asked me about the winding protocol for toroidal transformers seen in Amateur books and magazine articles. My correspondent included a partial circuit (**fig. 1A**) as an example of his dilemma. He wanted to know how to wind it and proposed a couple of methods. At first I thought the answer was obvious, then I realized that I was wrong — to many people it is not.

All windings are wound together in a "multifilar" manner. If there are three, we are talking about "trifilar" windings. **Figure 1B** shows the trifilar winding method. For clarity's sake, I have shown all three wires differently. Because most of my projects use No. 26, 28, or 30 enameled wire to wind coils, I keep three colors of each size on hand and use a different color for each winding.

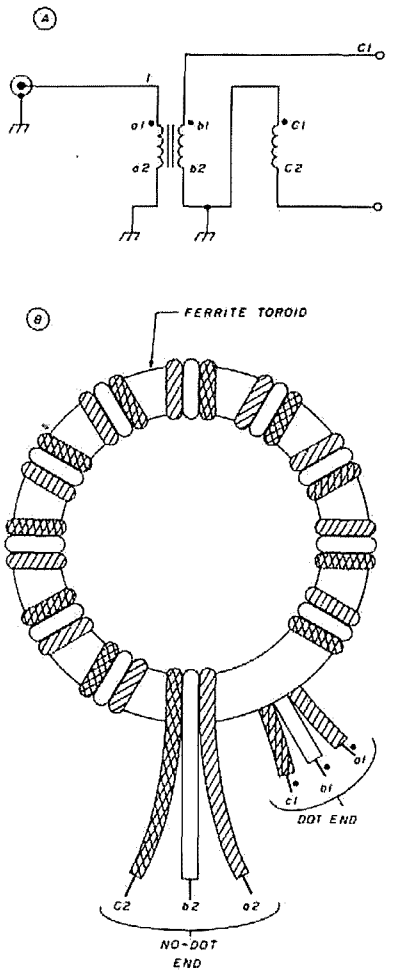


fig. 1. Three-winding transformer: (A) electrical diagram and (B) trifilar winding on a toroidal core.

The dots in the schematic and on the picture identify one end of the coil windings. The "dot" and "no-dot" ends are different from each other, and it usually makes a difference to circuit operation (signal phasing) which way the ends are connected into the circuit.

Figure 2 shows two accepted methods for winding a multifilar coil on a toroidal core. **Figure 2A** is the same method as in **fig. 1B**, but shows an actual toriod rather than a pictorial representation. As previously shown, the wires are laid down parallel to each other. The method in **fig. 2B** uses twisted wires. The three wires are chucked up in a drill and twisted together before being wound on the core. With one end of the wires secured in the drill chuck, anchor the other end to something that will hold it taut. (I use a bench vise.) Turn the drill on slow speed and let the wires twist together until you achieve the desired pitch.

Be very careful when performing this operation. If you don't have a variable speed electric drill that runs at very slow speed, use an old-fashioned manual drill. Remember to wear eye protection if you use an electric drill. If the wire breaks, or gets loose from its mooring at the end opposite the drill, it will whip around wildly until the drill stops. That whipping wire will cause painful welts on the skin, and can certainly cause eye damage.

Of the two methods for winding toroids, the method shown in **figs. 1B** and **2A** is preferred. When winding toroids, at least those of relatively few windings, pass the wire through the "doughnut" hole until the toroid is close to the midpoint of the wire. Loop the wire over the outside surface of the toroid, and pass it through the hole again. Repeat this process until the correct number of turns is wound onto the core. Be sure to press the wire against the toroid form and keep it taut as you wind the coils.

Enameled wire is usually used for toroid transformers and inductors, and this can lead to problems. The enamel can chip causing the copper conductor to contact the core. On larger cores, like those used for matching transformers and baluns at kilowatt power levels, the practical solution is to wrap the bare toroid core with a layer of fiber glass packing tape. Wrap the tape exactly as if it were wire, but overlap the turns slightly to ensure covering the entire surface of the core.

On some projects, particularly those in which the coils and transformers use very fine wire (like No. 30), I have found that the wire windings tend to unravel after the process is completed. To prevent this, place a tiny dab of rubber cement or silicone sealer at the ends of the windings (see **fig. 2C**).

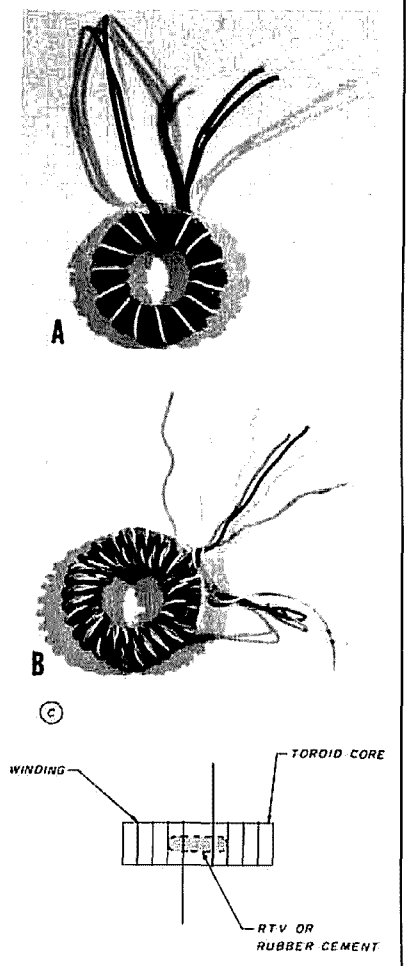


fig. 2. Winding methods and hints: (A) conventional turns, (B) twisted leads, and (C) secured winding with dab of glue or sealer.

mounting toroid cores

Now that you have a properly wound toroidal inductor or transformer, it is time to mount it in the circuit. There are three easy ways to do this. If the wire is strong enough, use the wire connections to the circuit board or terminal strip to support the component. If this is not satisfactory (and in mobile equipment or wherever else vibration is a factor it won't be), try laying the toroid flat on the board and cementing it in place with silicone

seal or rubber cement. For the third method, drill a hole in the wiring board and use a screw and nut to secure the toroid. *Do not use metallic hardware for mounting the toroid!* Metallic fasteners will alter the inductance of the component and possibly render it unusable. Use nylon hardware for mounting the inductor or transformer.

how many turns to use?

Three factors must be considered when making toroid transformers or inductors: toroid size, core material, and number of turns of wire. The toroid size is selected as a function of power handling capability or convenience. The core material is selected according to the frequency range of the circuit. The only thing left to vary is the number of turns. The size and core material yield a figure called the A_L factor. These values are given for several popular toroidal cores in **table 3**. The required value of inductance and the A_L factor are related by the following equation:

$$N = 100\sqrt{L/A_L} \qquad (1)$$

Where:

N is the number of turns

L is the inductance in microhenries

A_L is the core factor in microhenries per 100 turns

EXAMPLE

Calculate the number of turns required to make a 5-μH inductor on a T-50-6 core. From **table 3** we see that the A_L factor is 40.

Solution:

$$N = 100\sqrt{L/A_L} \qquad (2)$$
$$= 100\sqrt{5/40} = 35$$

Don't take the equation value too seriously; a wide tolerance exists on Amateur-grade ferrite cores. While this isn't too much of a problem when buildng transformers, it can be critical when making inductors for a tuned circuit. If you find that the tuned circuit takes considerably more or less capacitance when called for in the standard equation, and all of the stray capacitance is properly taken into consideration, then it may be that the actual A_L value of your particular core is different from the **table 3** value.

Table 3. Common A_L values.

Core	Core Materials Type (Mix)								
Size	26	3	15	1	2	6	10	12	0
12	–	60	50	48	20	17	12	7	3
16	–	61	55	44	22	19	13	8	3
20	–	90	65	52	27	22	16	10	3.5
37	275	120	90	80	40	30	25	15	4.9
50	320	175	135	100	49	40	31	18	6.4
68	420	195	180	115	57	47	32	21	7.5
94	590	248	200	160	84	70	58	32	10.6
130	785	350	250	200	110	96	–	–	15
200	895	425	–	250	120	100	–	–	–

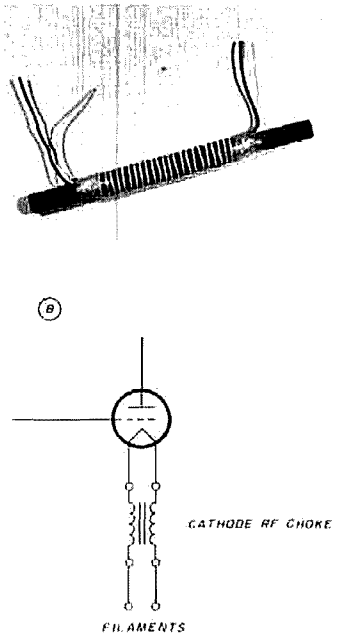


fig. 3. Ferrite rod filament choke: (A) physical winding and (B) used in tube cathode circuit.

ferrite rods

The rod shown in **fig. 3A** is another form of ferrite core available on the Amateur market. This type of core is used to make rf chokes, like the one used in the vacuum tube filament lines of a linear amplifier power tube (**fig. 3B**). The two windings are made in a bifilar manner over the ferrite rod. The wires used are heavy enough to carry the filament current of the tube. As in the toroidal transformer, I used two different wire colors to discriminate between windings.

Ferrite rods are also used in receiving antennas. Although few Amateurs have them, there are places where a ferrite rod antenna (or "loopstick") is used. For example, ferrite loops are common in radio direction-finding antennas. Some Amateurs report that they use a loopstick receiving antenna when operating on crowded bands like 40 or 75 meters. The small loopstick is extremely directional and is capable of nulling out interfering signals. Of course, one would not want to use the loopstick for transmitting, so there must be some means for switching between transmit and receive functions.

mounting ferrite rods

Ferrite rods can be mounted several ways; two of them are analogous to the methods used on toroids. You can mount the rod using either its own wires for support or a dab of cement or silicone sealer to fasten it to the board. Although you can't use simple nylon screws the way you can on toroids, you can use insulating cable clamps to secure the ends of the rod to the board.

Questions, suggestions, and criticisms are welcomed. Send them to: Joe Carr, K4IPV, POB 1099, Falls Church, Virginia 22041.

references

1. Amidon Associates, 12033 Otsego Street, North Hollywood, California 91607

2. *The 1988 ARRL Handbook for the Radio Amateur*; $20.95 plus $3.50 shipping and handling from *ham radio* Bookstore, Greenville, New Hampshire 03048.

ham radio

Yagi vs. Quad, Part 2

Optimized forward gain comparison

In part 1, we developed a means of analyzing quad antennas based on a mutual impedance versus spacing relationship and a fixed single quad element pattern. In part 2, we will examine different quad element configurations on a variety of boom lengths and attempt to maximize forward gain through fine tuning of the element lengths. Boom length will be limited to 1 wavelength or less because this is about the longest practical boom for 15, 20, or 40 meters.

The intent here is to answer the questions: What is the best possible forward gain we can squeeze out of a quad of a given boom length, and how much has the optimized gain improved from where we started? Note that we are not taking front/back discrimination or bandwidth into consideration. Both parameters are important, but both detract from maximized forward gain. Finally, we can compare the computed maximized gain for a quad against the maximized forward gain for a Yagi.

computational methodology

Antennas are modeled in free space using the assumptions outlined in part 1*. The mutual impedance between elements is assumed to be independent of element length. The self-impedance is approximated from interpolation of measured values. Gain is calculated from integration of field pattern over a sphere, and comparison of the forward field against the average power. Field points are updated every 10 degrees (both phi and theta, spherical coordinates).

Initial antenna design is based on general *ARRL Antenna Handbook* principles. Reflector length is 1030/f = 1.05 wavelengths. Driven elements are 1005/f = 1.021 wavelength. Directors are all 975/f = 0.991 wavelengths, and all elements are spaced equally along the boom. Starting with the reflector, the element length will be increased by 0.0025 wavelength and the gain again calculated. If the forward gain improves by at least 0.005 dBi, that element is incremented again in the same direction; if not, the element will be shortened until the gain starts to fall off. Once the reflector is optimized for forward gain, the same procedure is applied to the directors in order, and the process is repeated until no significant gain increase occurs with element change. The elements, except for the ones at the end of the boom, will then be moved along the boom in 0.0025 wavelength increments to attempt a further gain increase.

*Yagi vs Quad, Part 1, *ham radio*, May 1988, pg. 68.

two-element quad results

The optimized gain was about 8 dBi on a 0.115 or 0.172 wavelength boom (8 and 12 feet on 20 meters). Adding a third element was worthwhile, as gain increased to about 10 dBi for boom lengths of 0.258, 0.30, 0.343, 0.430, and 0.516. Initial performance of larger antennas was better. Quads on a 0.688 wavelength boom (48 feet on 20 meters) showed an initial gain of about 11 dBi which increased to just under 12 dBi with tuning. Quads on a 0.86 wavelength boom (60 feet on 20 meters) could be tuned for over 12 dBi, and on a 1.031 wavelength boom (72 feet on 20 meters) peaked at 12.7 dBi.

The relationship between maximum gain and boom length is compared against similar data developed for Yagi antennas[1] (**fig. 1**). The two-element quad is slightly better than a two-element Yagi (by 0.5 dBi or so) but worse than a three-element full-size Yagi (by 1.5 dBi), and a three-element quad is slightly better than a three- or four-element Yagi (again by 0.5 dBi). The quad antennas did not show the same staircase gain phenomenon observed with Yagi antennas[1], and *forward gain rose smoothly with increases in boom length out to 1 wavelength.* With Yagi antennas the gain versus boom length relationship is not smooth, but increases rapidly over a small extension in boom length and then plateaus. Thus, Yagi and quad antennas performed similarly out to a 24-foot boom on 20 meters, but past this point quad forward gain continued to increase and Yagi forward gain plateaued (**fig. 2**). Between 24- and 48-foot booms the quad showed up to 2.5 dB gain over the same size Yagi. Above 48

By David Donnelly, K2SS, 8 Alder Street, Lincoln Park, New Jersey 07035

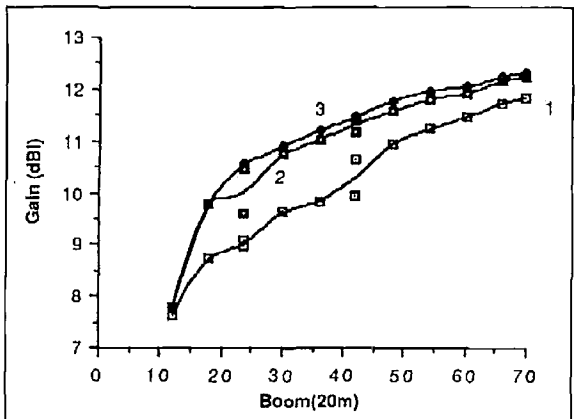


fig. 1. Forward gain versus boom length in feet for different 20-meter antennas. Line 1 (open squares) shows the original antennas; line 2 (filled squares) gives results after forward gain optimization by perturbation of element lengths; line 3 (filled triangles) shows what happens after element *and* spacing perturbation. Note the gain improvement with optimization was about 1 dB.

feet the Yagi closed the gap, reducing the quad advantage to about 1.5 dB.

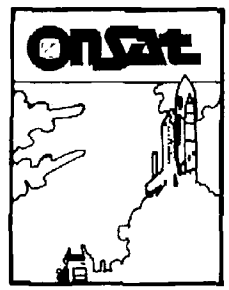
Several conclusions are suggested by these results: First, quad antenna gain, like Yagi gain, is basically a function of boom length and not the number of elements, as long as "enough" elements are used. Second, the quad may have 2 to 2.5 dB greater gain than a well-tuned Yagi, but this occurs only at certain boom lengths. The quad should work about 0.5 to 1.5 dB better for the same boom length. Third, the average gain increase expected with fine tuning is about 0.45 dB (range 0.0-1.55 dBi).

Lindsay's 440-MHz experimental results initially suggested that quads were somewhat better than Yagi antennas on the same-sized boom[2]. However, experimental uncertainties led to questions about his conclusions. For instance, it was difficult to measure gain accurately on the basis of input power because of inefficiencies in the coupling system.[3] This may have influenced Lindsay's measurements from the start, since he measured the gain of a quad loop as being 2 dB better than a dipole. The actual value, according to several sources, should be 1 dB. Another variable in Lindsay's study involved the lengths of Yagi and quad elements; they were cut by formula and not optimized for any particular factor like forward gain. Because fine tuning of a Yagi or quad may add another 1 dB or so to the forward gain, any gain difference between Yagi and quad antennas is reduced to the experimental noise.

Not all people have found quad antennas to be as good as Yagis. Driving around California with a 70-foot portable reference antenna, Wayne Overbeck com-

OnSat®

"America's Weekly Guide to Satellite TV"



The best in satellite programming! Featuring: ★ Over 120 Channels listed ★ Weekly, Updated Listings ★ Magazine Format ★ Complete Alphabetical Movie Listings ★ Sports Specials ★ Prime Time Grids ★ Specials ★Programming Updates!

- **Only $45.00 per year (52 weekly issues)**
- **2 Years $79.00 (104 weekly issues)**
- **$1.00 for sample copy**

*NC Residents must add 5% Sales Tax

Subscribe Today!

call toll free 1-800-234-0021
Visa® and MasterCard® accepted

OnSat PO Box 2347 Shelby, NC 28151-2347

STV GUIDE

The new **STV Guide** contains valuable information on zoning regulations, scrambling, plus technical tips for installing or updating a satellite system—and now a precise monthly guide to satellite TV with the latest program listings for over **90 channels**!



All this in each complete issue of **STV Guide**!

- **Only $48.00 per year (12 monthly issues)**
- **$2.00 for a sample copy**

*NC Residents must add 5% sales tax

Subscribe Today!

Call toll free 1-800-234-0021
Visa® and MasterCard® accepted

STV Guide PO Box 2384 Shelby, NC 28151-2384

Table 1. Element length, spacing, forward gain and front to back (at the horizon) for two, three, and four elements on 0.115, 0.258, 0.343, 0.430 and 0.516 wavelength booms (8, 12, 18, 20, 24, 30, and 36 feet on 20 meters). Row S is the starting antenna and row O is after forward gain optimization. The element length is specified first and the element position is in parentheses. R is the reflector; De is the driven element; D1..Dn are directors. Gain is specified over isotropic.

Element Length (boom position)								Gain(dBi)	F/B(dB)
(R)	(De)	(D1)	(D2)	(D3)	(D4)	(D5)	(D6)		
S 1.050(0)	1.021(.12)							7.64	20.8
O 1.035(0)	1.021(.12)							8.00	12.0
S 1.050(0)	1.021(.17)							7.65	14.4
O 1.037(0)	1.021(.17)							7.78	9.7
S 1.050(0)	1.021(.13)	0.991(.26)						8.76	13.0
O 1.030(0)	1.021(.13)	1.013(.26)						9.84	10.2
S 1.050(0)	1.021(.15)	0.991(.30)						8.99	15.2
O 1.035(0)	1.021(.15)	1.013(.30)						9.72	9.1
S 1.050(0)	1.021(.12)	0.991(.23)	0.991(.34)					9.03	10.0
O 1.030(0)	1.021(.12)	1.008(.23)	1.021(.34)					10.42	14.0
S 1.050(0)	1.021(.11)	0.991(.22)	0.991(.33)	0.991(.43)				9.65	15.0
O 1.027(0)	1.021(.11)	1.011(22)	1.021(.33)	1.016(.43)				11.22	16.4
S 1.050(0)	1.021(.13)	0.991(.26)	0.991(.39)	0.991(.52)				10.28	25.5
O 1.037(0)	1.021(.13)	1.011(.26)	1.021(.39)	1.021(.52)				11.52	17.0
S 1.050(0)	1.021(.17)	0.991(.34)	0.991(.52)	0.991(.69)				10.97	25.4
O 1.039(0)	1.021(.15)	1.011(.30)	1.021(.52)	1.003(.69)				11.78	16.0
S 1.050(0)	1.021(.17)	0.991(.34)	0.991(.52)	0.991(.69)	0.991(.86)			11.48	12.6
O 1.040(0)	1.021(.17)	1.001(.34)	0.963(.52)	1.016(.69)	1.011(.86)			11.99	13.6
S 1.050(0)	1.021(.15)	0.991(.29)	0.991(.44)	0.991(.59)	0.991(.74)	0.991(.88)	0.991(1.03)	11.96	43.8
O 1.035(0)	1.021(.15)	1.006(.29)	0.971(.44)	0.988(.59)	0.991(.74)	0.988(.88)	1.026(1.03)	12.59	16.8

pared low-angle signal strengths of Yagi and quad antennas at various QTHs against a portable reference antenna at the same height as the test antenna[3]. A review of his results showed that quads were the same as or inferior to Yagi antennas, and certainly not 2 dB better than similar Yagi antennas. Why didn't the quads perform better?

Theoretical results presented here suggest that quad antennas with correct coupling should be at least as good as Yagis, and certainly not worse. But two complicating factors were not included in the computer model: the efficiency of the feed system and the effects of nonresonant elements in the vicinity of the antenna. Most of the antennas showing the best performance in Overbeck's study were monoband Yagis with a double driven element. This feed system, popularized by KLM, is known for its wide bandwidth and low SWR, and is also said to give excellent results on quad antennas.[5] Perhaps part of the answer lies in a lower feed efficiency for direct feed quads. Attaching the coax to the quad loop is the most common method of feeding quads. Most quad antennas are implemented as tribanders with wires for other bands in close proximity to the desired antenna. It may be that these other wires significantly degrade performance. Both of these factors deserve a closer look.

I didn't intend to provide optimum dimensions for quad loops, and a caveat is in order if you wish to use the dimensions provided in Table 1. Although I believe

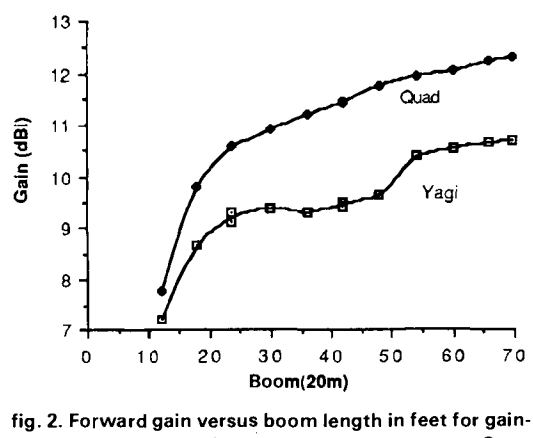


fig. 2. Forward gain versus boom length in feet for gain-optimized 20-meter Yagi and quad antennas. Open squares represent gain-optimized Yagi antennas from a previous article.[1] The quad line shows optimized gain from *fig. 1*. Quad antennas may have a 2-dB advantage over a Yagi on the same length boom, but only at specific boom lengths.

in the results of computer modeling, the dimensions should be trusted only after confirmation on an antenna test range. I have not done this, and the actual performance peaks may be different. The constructed quad loops should have the same reactance as the computer antenna. The best way to do this is to direct-

ly measure reactance with an impedance bridge and trim the element accordingly.

summary

Quad antennas offer a theoretical 0.5 to 2.5 dB advantage over a Yagi of the same boom length. Like the Yagi, a gain increase of about 1 dB may be obtained through fine tuning of the elements. The increase in forward gain as one goes to longer boom lengths is smoother for quad antennas than for Yagis, and quads do not show the gain plateau seen with Yagi antennas. Finally, the quad should be significantly better than the Yagi, especially between boom lengths of 25 and 45 feet on 20 meters. However, unknown variables such as feed system efficiency or the effect of other wires in close proximity to the quad may detract from its theoretical performance.

references

1. D.F. Donnelly, "Optimizing Gain on Yagi Antennas," *ham radio*, March 1988, page 21-24.
2. J.E. Lindsay, "Quads and Yagis," *QST* May 1968, page 11-19
3. W. Overbeck, "Quads and Yagis Revisited," *ham radio*, May 1979, page 12-21.
4. B. Myers, "The W2PV Four element Yagi," *QST*, October 1986, page 15-19.
5. R. Martinez, "The Evolution of the Four-element Double driven Quad Antenna," *CQ*, December 1983, page 30-36.
6. J.L. Lawson, "Yagi Antenna Design: Quads and Quagis," *ham radio*, September 1980, page 37-45.

W6SAI BOOKS

published by Bill Orr, W6SAI and Stu Cowan, W2LX

BEAM ANTENNA HANDBOOK
Completely revised and updated with the latest computer generated information on BEAM Antenna design. Covers HF and VHF Yagis and 10, 18 and 24 MHz WARC bands. Everything you need to know. 204 illustrations. 268 pages. ©1985. Revised 1st edition
IRP-BA — Softbound $11.95

SIMPLE LOW-COST WIRE ANTENNAS
Primer on how-to-build simple low cost wire antennas. Includes invisible designs for apartment dwellers. Full of diagrams and schematics. 192 pages. ©1972 2nd edition
IRP-WA — Softbound $11.95

ALL ABOUT CUBICAL QUAD ANTENNAS
Simple to build, lightweight, and high performance make the Quad at DX'ers delight. Everything from the single element to a multi-element monster. A wealth of information on construction, feeding, tuning and installing the quad antenna. 112 pages. ©1982 3rd edition
IRP-CQ — Softbound $9.95

THE RADIO AMATEUR ANTENNA HANDBOOK
A wealth of projects that covers verticals, long wires, beams as well as plenty of other interesting designs. It includes an honest judgement of gain figures, how to site your antenna for the best performance, a look at the Yagi-Quad controversy, baluns, slopers, and delta loops. Practical antenna projects that work! 190 pages. ©1978 1st edition
IRP-AH — Softbound $11.95

Please enclose $3.50 for shipping and handling

VISA MasterCard

ham radio magazine BOOKSTORE
GREENVILLE, NH 03048 (603) 878-1441

CTM

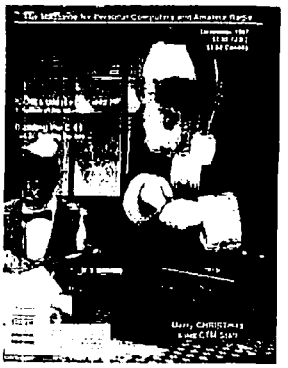
Hey LOOK !
Your Friends have been talking!

The Secret's Out !

CTM

CTM is the ham radio and computer magazine with that "down home flavor", dedicated to the practical aspects of Amateur Communications. Just starting out? You'll find our well-illustrated tutorials friendly and open; we show you how. If your interest is in High Tech, you'll find reviews and user reports of the latest thing to come down the pike and they are written so you can understand them too! If your interest is in training, you'll find articles for ham radio, computers and emergency communications.

You'll find it **ALL** in CTM



$18. year U.S. - 6 Months $10.
Mexico & Canada $32. year
Other Countries (air) $68. (Surface) $43.

There is always time for some friendly fun that you don't need a license to enjoy — and appreciate...

Are you into **Packet Radio?** Thinking about it? Then you **definitely** need **CTM!** During 1987 we had **65** packet and packet related articles and that doesn't even count the other **HAM** articles or the many **Computer** articles. The other four ham magazines* only had 26 packet articles during 1987. There's something for everyone in **CTM!** Jump right in, you'll find the natives friendly — and helpful, too!

*CQ™ 5 articles; *Ham Radio*™ 10 articles; *QST*™ 5 articles and *73*™ 6 articles = 26 articles for 1987 for the other ham magazines...

NOW which do you need to SUBSCRIBE?
CTM of course!

VISA Add 5% for credit cards MasterCard

Name:
Call Sign:
Address:
City: ST ZIP
Phone No. ( )

CTM Magazine
Circulation Manager
1704 Sam Drive
Birmingham, AL 35235
(205) 854-0271

NEW products

new coaxial crimping tools

Nemal Electronics International has introduced two new crimping tools that combine the capabilities of several tools. They offer full cycle ratchet operation with machined dies for precision crimping and long service life. By combining multiple hex sizes in a single fixed die, the tools provide great versatility and cost savings.

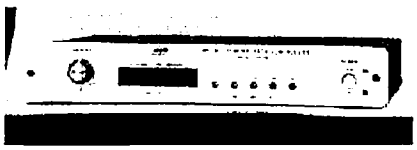
Part No. CT3500 crimps a wide variety of BNC, TNC, type N, and other rf connectors on RG58, 59, 62, 142, and 223-size cables. Part No. CT3600 offers the capability of crimping both RG59 and Belden 8281 connectors without changing dies. Both tools provide a ratchet release lever to allow adjustment of cable or connector position during the crimp cycle.

For additional information please contact Nemal Electronics International, Inc., 12240 NE 14th Ave., North Miami, Florida 33161.

multi-mode data controller

The new MFJ-1278 Multi-mode Data Controller by MFJ Enterprises, Inc. lets you work seven digital modes: Packet, ASCII, RTTY, CW, WEFAX, SSTV, and Contest Memory Keyer.

Features include high performance hf/VHF/CW modems, software selectable dual radio ports, precision tuning indicator, 32K RAM, and an ac power supply.



To operate the MFJ-1278 you need a standard hf or VHF rig and a computer with a serial port and terminal program.

MFJ also offers a Starter Pack that includes computer interface cable, terminal software, and instructions. It is available for the Commodore 64/128, VIC-20 (MFJ-1287, disk; MFJ-1283, tape) and for the IBM or compatible (MFJ-1284), $19.95 each.

The MFJ-1278 automatically sets itself to match your computer baud rate. All modes feature printing, threshold control for varying band conditions, tune-up command, lithium battery backup, RS-232 and TTL serial ports, watch dog timer, FSK and AFSK outputs, output level control, speaker jack for both radio ports, test and calibration software, Z-80 microprocessor running at 4.9 MHz, 32K EPROM and socketed ICs. It is FCC approved, measures 9 x 1-1/2 x 9-1/2 inches and operates on either 12 VDC or 110 VAC.

The MFJ-1278 is backed by a one-year unconditional guarantee. It can be ordered for $249.95 and may be returned within 30 days for a full refund, less shipping.

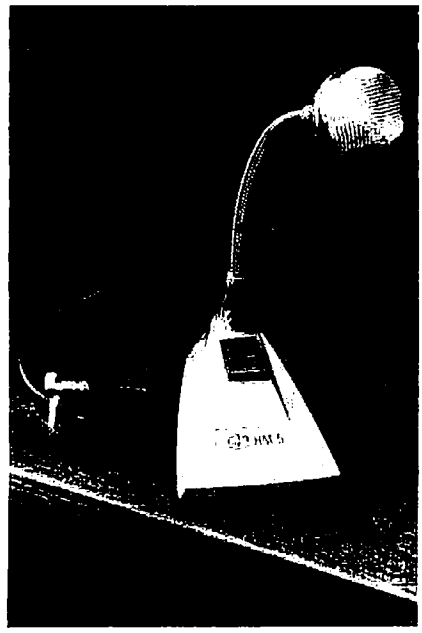
For details contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #301 on Reader Service Card.

microphone for SSB/fm

Heil Sound has just released its HM-5 microphone with the HC-5 "Key Element" cartridge developed for SSB.

The HM-5 has a cast base with a 10 x 1/4 inch "easy-move" goose neck. A push-to-talk switch has single touch activation or can be locked down for longer transmissions. An eight-wire flexible cable is attached. The response is 300-2,800 Hz with an 8-dB spike at 2,000 Hz for increased articulation.



For additional information contact Heil Sound, Marissa, Illinois 62257.

Circle #304 on Reader Service Card.

Macket software for Macintosh

Macket provides power and flexibility for the packet operator with a Mac™. There are windows for entering text, displaying the receive buffer, and logging transmitted text. The windows support all the features Mac users expect. The input window allows mouse-based editing. Other features include text uploading and downloading, printing, and macro keys.

Macket works with all Pac-Comm TNCs, the TNC-200, TNC-220, Tiny-2 TNC, and the Micro-power-2 TNC as well as any TNC with an RS-232 port. When used with a TNC-2 clone that has the RXBLOCK command, Macket can display the user's conversations in a special window so the conversation will not be mixed with monitored text.

Macket's suggested retail price is $39.95. The program, developed by 'S Fine Software' is available from Pac-Comm Packet Radio Systems, Inc., 3652 W. Cypress St., Tampa, Florida 33607.

Circle #302 on Reader Service Card.

dual meter wattmeters

Encomm, Inc. announces the addition of several wattmeters to their Santec line. They are actually "dual" meter wattmeters in several different models. Model W-710 covers 1.6-60 MHz and has three power levels of 2k/200/20w. Model W-720 covers 1.8-200 MHz with power levels of 200/60/15w. The W-740 has the same power levels as the W-720 but with frequency coverage of 140-525 MHz. Housed in a sturdy metal case the meters are basically unaffected by stray rf fields.

Contact Encomm Inc., 1506 Capital Ave., Piano, Texas 75074 for more information.

Circle #303 on Reader Service Card.

tri-band base and mobile antennas

NCG Company now has new Tri-Band SLC system antennas for operation on 145, 446 MHz and 1.2 GHz. Both are SLC (Super Linear Converter) system antennas. They are waterproof with lightning protection. The base antenna is model CX-901; the mobile is CX-801.

Features of the CX-901 include one-piece construction of heavy-duty fiber glass. The mast diameter is 1.25 to 2.5 inches, the length is 3 feet, 4 inches, and it weighs 1 lb., 14 oz. This base antenna handles 150 watts, with frequency and gain of 144-148 MHz 3.0 dB, 440-449 MHz 6.0 dB, and 1260-1300 MHz 8.4 dB.

The CX-801 mobile unit is a one-touch, fold-over stainless steel, with an N connector for low loss, high gain. The maximum power handled is 100 watts. The antenna is 3 feet, 3 inches long and weighs 12 ounces. Frequency and gain for the CX-801 is 144-148 MHz 3.0 dB, 440-449 MHz 6.8 dB, and 1260-1300 MHz 9.6 dB.

Both antennas are designed for use with the new Tri-Plexer CFX-4310 that allows receiving and transmitting on all three bands at the same time. With one CFX-4310 it is possible to use only one coax for all three transceivers. Using the new Tri-Band transceiver you can operate three antennas from one transceiver.

Think you've seen it all?
TAKE A LOOK AT THIS!



Send check or money order to:
(US Funds only. Incl. $2 S/H)

MORLAN SOFTWARE
P.O. Box 2400
EAST LIVERPOOL, OH 43920-0400
THANK DAYTON

112

18th ANNUAL
INDIANAPOLIS HAMFEST™
And Indiana State ARRL Convention
And Computer Show
July 9-10, 1988

Marion County Fairgrounds —
Gates open 6:00 AM both days

2 Full Days of: Commercial Exhibitors, Large Flea Market, Hourly Awards, Forums
FREE: Parking, Kids Awards, Camping, Womens Awards

Indiana's Largest Electronic Flea Market, Amateur Radio and Computer Display

INDIANAPOLIS HAMFEST,
P. O. Box 11776, Indianapolis, IN 46201
CALL: (317) 745-6389—Commercial
(317) 356-4451—Flea Market

Multiband QRV 160-10 Emergency Pack

Field Day Winner
The Emergency Pack contains QRV 160-10 All Band kink-proof weather sealed antenna, Quick Launch kit, 70' RG-8x feedline, 160 meter adapter, all band counterpoise, 200' rotproof line. Complete and QRV. One person installs in 15 minutes.

Fastest Antenna in the West
$139.95
+$10 P&H
incl 47 page Tech Manual
Info: 56c s.a.s.e

1971 N. Oak Lane 1300 E.
Provo, UT 84604-2138
AntennasWest
(801) 374-1084

107

NEW products

The new 5D-FB 50-ohm coax, usable above 1200 MHz, is a solid copper center conductor with a PEF insulation, foil wrapped, TFE insulation, full braid, and black PVC weather jacket. N type connectors are available.

For information on the Tri-Band antennas, Tri-Plexers, and 5D-FB coax contact NCG Company, 1275 N. Grove Street, Anaheim, California 92806.

Circle #305 on Reader Service Card.

RC-96 repeater controller

Advanced Computer Controls, Inc. offers the RC-96 Repeater Controller. Remote programming lets the operator make changes to his repeater easily without a trip to the site.

The '96 features autopatch and autodialer, with storage for 200 telephone numbers. The talking S-meter lets the user check signal strength into the repeater. The controller also supports pocket pagers, linking to other repeaters, and a bulletin board. It has high-quality synthesized voice with ACC's large, custom speech vocabulary.



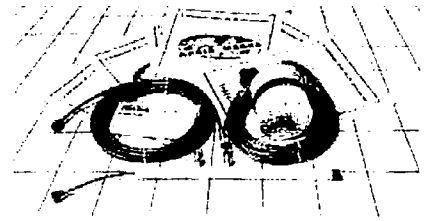
The '96 has built-in keypad and indicators, shielded DIN cables for easy hookup, and easily accessible pots and DIP switches in the back. The risk of lightning damage is minimized by a gas discharge tube across the phone line and transient suppressors on each I/O signal.

Contact Advanced Computer Controls, Inc., 2356 Walsh Avenue, Santa Clara, California 95051.

Circle #306 on Reader Service Card.

the Carolina Windom

The Radio Works has introduced the new Carolina Windom®, a high performance, 80-10 meter antenna system. While not a windom in the classic sense, its off-center feed system suggests the name. Fed with 50-ohm coax, it produces a low SWR across nearly all of the 75/80 meter band. Operation on 40-10 meters requires a transmatch.



The Carolina Windom comes with a special dedicated matching unit, vertical radiator section, high power line isolator, No. 14 stranded antenna wire, and glass-filled insulators. The package includes CoaxSeal® and an illustrated manual.

The price is $75, complete and ready to install. For more information, contact Jim Thompson, W4THU, Radio Works, Box 6159, Portsmouth, Virginia 23503. A catalog offering a wide selection of wire antennas, parts and accessories is available on request.

Circle #307 on Reader Service Card.

MAXFAX™ and WEFAX

Kantronics has added a weather facsimile command, WEFAX, with EPROM update 2.8. This update is available for the KAM, KPC-4, KPC-2, KPC-1, and the KPC-2400. In addition, Kantronics introduces two programs to work with the KAM or KPCs, MAXFAX-64/128 for Commodores and MAXFAX-PC for PCs and compatibles. If you use a PC, the CGA Icolor graphics adapter) is required.

With MAXFAX, you can store the pixel bytes from the KAM or KPC directly In RAM to the screen, or from RAM to diskette for transport or to your graphics printer. An Epson graphics format such as the EPSON LX-80 is assumed. Each MAXFAX copy comes on diskette and costs $19.95. You can order from Kantronics, Inc., 1202 E. 23rd Street, Lawrence, Kansas 66046.

Circle #308 on Reader Service Card.

new rf/high-voltage adapters

Nemal Electronics International offers a new line of rf adapters for quick and reliable interconnections between different connector series. These adapters facilitate rapid interconnection of incompatible cables and equipment while maintaining low loss and VSWR.

The NE964 adapts a type HN jack to an SMA plug; the NE962 adapts an SMA jack to a type HN plug; and the NE970 adapts a type N jack to an LC plug. The NE866 is a BNC series bulkhead feedthrough with both isolation and hermetic seal.

Constructed of brass and plated silver/nickel, these adapters have Teflon™ insulation and tolerate temperatures of 55C to +199C. Other specifications include an impedance of 50 ohms,

frequency of 0-4 GHz, VSWR of 1.3, and voltage rating of 375/1500. The adapters offer electrical performance and construction to military specifications.

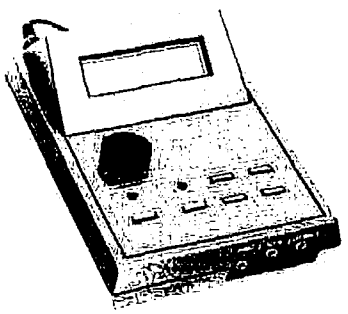
For details contact Nemal Electronics International Inc., 12240 NE 14th Ave., North Miami, Florida 33161.

Circle #309 on Reader Service Card.

AR-501 radio telegraph terminal

ACE Communications, Inc.'s model AR-501 is a triple-mode radio telegraph (CW) terminal for Amateur Radio operator, and short wave listeners.

The AR-501 performs as a CW decoder, CW trainer, and electronic keyer. Features include: automatic speed follow-up and threshold control, LED tuning indicator, 32-character LCD display, random code generator, and electronic keyer for both standard and iambic. Codes can be monitored in all three modes by internal speaker and printer through the parallel printer port.



It measures 4.5 x 6.25 x 2.25 inches and is powered by a 12 VDC source. The price of the AR-501 is $229.00 including ac power adapter and parts for hookup.

For more details contact ACE Communications, Inc., 22511 Aspan St., El Toro, California 92630-6321.

Circle #310 on Reader Service Card.

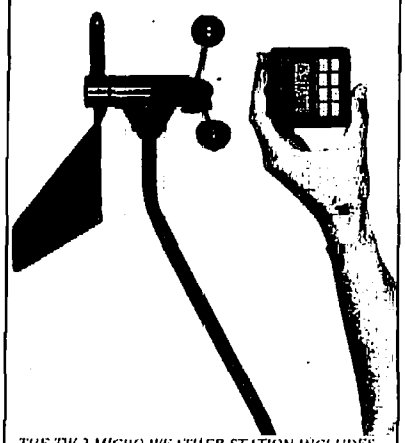
high-quality variable capacitors

Kilo-Tec announces the availability of the Nevada High-Power variable capacitors. They are capable of withstanding very high rf voltage up to 7.8 kV. These heavy-duty caps are suitable for high-power antenna matching units, power amplifiers, and transmitters.

There are two values: a 500 pF and a 250 pF. Approximate prices are $29 for the TC-250 and $40 for the TC-500. To order or receive a quote contact Kilo-Tec, PO Box 1001, Oak View, California 93022.

Circle #311 on Reader Service Card.

WORLD'S SMALLEST——
——WEATHER STATION



THE TW-2 MICRO WEATHER STATION INCLUDES A COMPUTER MODULE, THE AN-2 ANEMOMETER, AND 40' OF LEAD IN CABLE. FOR ONLY $159.95.

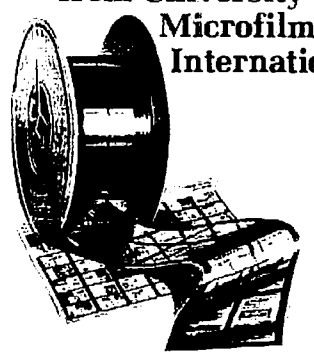
WIND SPEED
WIND DIRECTION
WIND CHILL
WIND GUST RECORD
TEMPERATURE
HI/LOW TEMP RECORD
AUTO SCAN
METRIC / STANDARD
FOUR WAY POWER
NICAD READY
MOUNTING OPTIONS
ONE YEAR WARRANTY

• • SATISFACTION GUARANTEED • •

MAGNAPHASE INDUSTRIES, INC.
MADE IN U.S.A. 1502 PIKE STREET N.W. AUBURN, WA 98001 M/C & VISA
ORDERS ONLY: 800-322-1502
INFORMATION: 206-735-0374 FAX: 206-735-9044

113

This publication is available in microform from University Microfilms International.



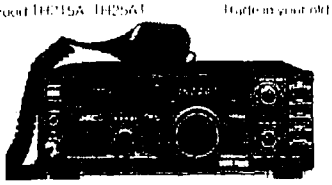
Please send information about these titles:

Name
Company/Institution
Address
City
State Zip
Phone

Call toll-free 800-521-3044. In Michigan, Alaska and Hawaii call collect 313-761-4700. Or mail inquiry to: University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106.

MADISON SHOPPER

CALL FOR ORDERS
1 (800) 231-3057
1-713-520-7300 OR 1-713-520-0550
TEXAS ORDERS CALL COLLECT
FAX 1-713-771-7759
ALL ITEMS ARE GUARANTEED OR SALES PRICE REFUNDED





Kenwood TS-140S — Call for trade
New Kenwood TM-221A 45W mobile — Call
ICOM 2GE-TM — 440.00

Icom 761 — 2300.00
Stone 444D — 94.95
HEIL BM10 Boom Mike wired 8 pin — 69.00
HEIL HM5 Desk Mike — 99.00
Pro HR 2AIA w/cabinet — Call
Cushcraft 32-4 WB (146 MHz) — 85.00
Butternut HF6V 80-10 vertical — 125.00
Hustler G7-144 — 119.95
KLM KT-34A — 899.00
NEW KLM LP-440 BX — 529.00
G5 RV — 44.00
Larsen 2 meter mobiles — 49.95
Antenna 2M 5/8 Mag Mount Comp — 5.00
Van Gordon 5/8WO — 44.00
Valor ABS mobile — 79.00
Thousands of used meters — 3.95 up/CALL
Astron 1000 pl 500 V Ammeter pl 58 — 1.95
Transformer 120 V Pri 1050 V 1A Sec #18 Wire — 50.00
100 pfd 450V Axial Cap — 2.50
#2USP PL259 Skeptable (Amphenol) — 1.95
82-61 N Male Amphenol — 5.00
Double Female UHF — 1.00
UG176/U — each .50
GE 6146B — 14.95
3-500Z — 130.00
GE 4CX350A — 7.00
6MJ6 — 2.99
6KD6 — 2.95
Cetron 572B — 86.00
6JB6A — 9.95
8950 — 18.00
ALA PK 202 Mobile new WCLA — 299.00
Kantronics KPC II — 349.00
Kantronics KAM/WA — 299.00

USED EQUIPMENT
All equipment used, clean, with 90 day warranty, and 30 day trial. Serviceable, full trade on used or new equipment. Sales price refunded if not satisfied.
Call for latest used gear
(800) 231-3057

GNU PROD
IL Systems 2m Amp (30 Watt) out/4 in — $249.00

POLICIES
Money orders $1000 Max. Cert. Bank or C.O.D. All prices FOB Houston. Accepted only. Prices subject to change without notice. Items subject to prior sale. Call prior to check the status of your order. Insurance optional, add 3% to bill. All items full factory warranty thru Madison warranty.

Bird and Belden products in stock. Call today.

MADISON
Electronics Supply
3621 FANNIN
HOUSTON, TEXAS 77004
MasterCard VISA

186



DX FORECASTER

Gerth Stonehocker, KØRYW

sporadic E season—1988

This is the second summer after the end of solar cycle 21. What kind of sprodic E conditions can we expect? In the period from May through September radiation from the nearly overhead sun generates high ion densities in the lower ionosphere that support short-skip propagation, including multiple short skips. The geomagnetic field clusters these ions into cloud-like patches known as sporadic-E (E_s). These patches form a thin layer of intense ionization in the E region about 60 miles up. A patch gives a strong, mirror-like signal reflection over skip distances of 600 to 1200 miles. Signals remain strong for about half an hour, up to a couple of hours after the onset of the first strong signal.

The frequency and magnitude of Sporadic E occurrences is a function of geographical location. The best locations for E_s openings this summer are toward the equator and on either side of the geomagnetic equator. It's especially good where the geomagnetic equator is furthest from the geographic equator. The Northern Hemisphere areas are: Southeast Asia (best) and the Mediterranean (next best) followed by South America in the Southern Hemisphere. These were shown graphically in this column last year on a contour map.

The highest frequency propagated by E_s tends to occur at local noon. The E_s patch is imbedded in the regular E layer and tends to track the E maximum ion density throughout the day, season, and sunspot cycle. During this summer expect about a 17 percent increase in the E layer as an E_s base for higher maximum usable frequencies (MUF) over a 1200 mile hop. This increase gives the base MUFs of 47 to 53 MHz this year, so six meter openings should be more prevalent. Two meter openings may still be rare, especially this month; perhaps August will provide some. The highest probability of occurrence is near sunrise and again around sunset. These two E_s characteristics affect short-skip openings differently. Openings on the higher-frequency bands occur around local noontime; the lower bands tend to have openings near sunrise and sunset. This occurrence characteristic is nearly constant over the sunspot cycle so there should be the same number of low to midlatitude E_s openings in the next few years.

last-minute forecast

Expect the higher frequency DX bands to be very good during the first two weeks of June because of solar flux peaks and longer daytime hours. Both factors contribute to elevated MUFs during the evening at midlatitude locations. No single hop transequatorial openings are expected but look for good sporadic E openings around noon toward the end of the month. Good nighttime DX conditions on the lower bands are expected during the last two weeks of the month, but they will be noticeably shorter in duration and noisier as northern tropical thunderstorm noise propagates toward us. Geomagnetic disturbances are anticipated from solar flares around the 5th, more probable on the 13th, and from coronal thinning on the 18th through 24th of the month. MUFs should decrease about 15 percent on east-west propagation paths on most days and probably 20 percent on those paths during disturbed conditions on the 13th. Signals should be 10 to 15 dB lower level and QSB will be noticed. Paths near the equator can expect 10 percent higher MUFs.

The moon will be full on June 29th and at perigee (its closest approach) on June 5th. Summer solstice is on the 21st at 0357 UTC. The Aquarid meteor shower starts about the 8th, peaks around the 28th, and lasts until about August 7th. The maximum radio-echo rate will be 34 per hour.

band-by-band summary

Six meters will provide occasional openings to South Africa and South America around noontime via short-skip E_s propagation.

There will be long-skip conditions on ten meters in the afternoon during the peak times of the 27-day solar cycle. Otherwise, look to sporadic-E short-skip and multihop openings around

JUNE

GMT	PDT	WESTERN USA N	NE	E	SE	S	SW	W	NW	MDT	MID USA N	NE	E	SE	S	SW	W	NW	CDT	EDT	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	5:00	20	15	15	12	20*	10	10	15	6:00	20	15	15	15	20	10	10	20	7:00	8:00	20	20	15	15	20	10	10	20*
0100	6:00	20	15	15	10	20	10	10	15	7:00	20	15	15	15	20	10	10	20	8:00	9:00	20	20	15	15	20	10	10	15
0200	7:00	20	15	20	10	20	10	10	15	8:00	20	15	20*	20*	20	10	10	15	9:00	10:00	20	20	20	20	20	10	10	15
0300	8:00	20	20	20	10	30	10	10	15	9:00	20	20	20	20	30	10	10	15	10:00	11:00	20	20	20	20	30	10	10	15
0400	9:00	20*	20	20	10	30	10	10	15	10:00	20	20	20	20	30	10	10	15	11:00	12:00	20	20	20	20	30	10	10	15
0500	10:00	15	20	20	12	30	12	10	15	11:00	20	20	20	20	30	12	12	15	12:00	1:00	20	20	20	20	30	12	10	15
0600	11:00	15	20	20	12	30	12	12	15	12:00	20	20	20	20	30	12	12	15	1:00	2:00	20	*30*	20	20	30	15	12	15
0700	12:00	15	*20*	20	15	30	12	12	15	1:00	20	20	20	20	30	15	12	20	2:00	3:00	*20*	*30*	20	20	30	15	12	20*
0800	1:00	15	*20*	*20*	*15*	30	15	15	20	2:00	*20*	*20*	*20*	20	30	15	15	20	3:00	4:00	*20*	*30*	20	20	30	20	15	20
0900	2:00	20	*20*	*20*	*20*	*30*	15	15	20	3:00	*20*	*20*	*20*	*20*	*30*	20	15	20	4:00	5:00	*20*	*30*	20	*20*	*30*	20	*20*	*20*
1000	3:00	*20*	*20*	*20*	20	*30*	15	15	20	4:00	*20*	*20*	*20*	*20*	*30*	*20*	20	*20*	5:00	6:00	*20*	*30*	*20*	*20*	*30*	*20*	*20*	*20*
1100	4:00	*20*	20	*15*	20	*30*	*20*	20	*20*	5:00	*20*	*20*	*15*	*15*	*30*	*20*	*20*	*20*	6:00	7:00	*20*	*30*	*20*	*20*	*30*	*20*	*20*	*20*
1200	5:00	*20*	20	15	20	*30*	*20*	*20*	*20*	6:00	*20*	20	15	15	*30*	*20*	*20*	*20*	7:00	8:00	*20*	*30*	*15*	*20*	*30*	*20*	*20*	*20*
1300	6:00	*20*	20	15	20	*30*	*20*	*20*	*30*	7:00	*20*	20	15	15	*30*	*20*	*20*	*20*	8:00	9:00	20	20	15	15	*30*	*20*	*20*	*20*
1400	7:00	*20*	20	12	20	*30*	*20*	*20*	*30*	8:00	20	20	12	12	*30*	*20*	*20*	*20*	9:00	10:00	20	20	15	15	*30*	*20*	*20*	*20*
1500	8:00	20	20	12	20	*30*	20	*20*	*30*	9:00	20	20	12	12	*30*	20	20	*20*	10:00	11:00	20*	20	12	15	*30*	*20*	*20*	*20*
1600	9:00	20	20	10	20	20	20	20	20	10:00	15	20	10	10	20	20	20	20	11:00	12:00	15	20	12	12	20	20	*20*	*20*
1700	10:00	20	20	10	20	20	20	20	20	11:00	15	20	10	10	20	15	20	20	12:00	1:00	15	20	10	12	20	20	*20*	20
1800	11:00	20	20	10	15	20	15	15	20	12:00	15	20	10	10	20	15	15	20	1:00	2:00	15	20	10	10	20	20	20	20
1900	12:00	20	20	10	15	20	15	15	20	1:00	15	20	10	10	20	12	12	20	2:00	3:00	15	20	10	10	20	12	15	20
2000	1:00	20	20	10	15	20	12	15	20	2:00	15	20	10	12	20	12	12	20	3:00	4:00	15	20	10	12	20	12	12	20
2100	2:00	20	15	12	12	20*	12	12	20	3:00	15	15	12	12	20	12	12	20	4:00	5:00	15	20	12	12	20	12	12	20
2200	3:00	20	15	15	12	15	12	12	20	4:00	20	15	12	15	20	10	10	20	5:00	6:00	20	20	15	15	20	10	12	20
2300	4:00	20	15	15	12	15	10	10	15	5:00	20	15	15	15	20	10	10	20	6:00	7:00	20	20	15	15	20	10	10	20
		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			CARIBBEAN S. AMERICA							

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next **higher** band for possible openings.

local noon for DX on this band. (Evening transequatorial openings usually don't occur in the summertime.)

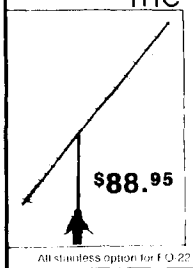
Twelve and fifteen meters, almost always open to some southern part of the world, will be the main daytime DX bands. Operate on 12 first, then move down to 15. DX is considered 5000 to 7000 miles on these bands. There may be some long, one-hop transequatorial propagation paths occurring early in the month.

Twenty, thirty, and forty meters will support DX propagation from most areas of the world during the daytime and into the evening hours most days. Forty meters joins this daytime DX group because of lower signal absorption, and therefore lower LUF (lowest usable frequency) during this last sunspot minimum year. DX on these bands may be either long-skip to 2500 miles or short-skip E_s to 1250 miles per hop. There are many good hours of DXing ahead as the days get longer.

Thirty, forty, eighty, and one-sixty are all good for nighttime DX. Although the background thunderstorm noise is becoming noticeable, these bands are still quiet enough to provide good DX working conditions. Sporadic-E propagation may be a contributing factor toward enhanced conditions at local sunset and will occur more often during the next three months.

ham radio

The Finest 432 MHz Yagis
EME — Tropo — Weak Signal
The FO-22



ELECTRICAL SPECIFICATIONS:
Measured gain 15.8 dBd
E-Plane beamwidth 2 x 11.5 deg
H-Plane beamwidth 2 x 12 deg
Sidelobe attenuation
1st E Plane sidelobe 17.5 dB
1st H Plane sidelobe ~15.5 dB
F/B ratio 22 dB
SWR <1.4:1 422-439 MHz
MECHANICAL SPECIFICATIONS:
Length: 14 ft.
Wind survival: 90 + MPH
Wind Surface Area: .78 sq. ft.
Coax connector: N-type
Mast: up to 1.5" diameter
Element insulators: U.V. resistant black Delrin
Stainless steel hardware (except plated keepers and U bolt)

$88.95

All stainless option for FO-22 (keepers and U bolt) $10.78

ALSO AVAILABLE
The incomparable FO-25 and FO-33
STACKING FRAMES POWER DIVIDERS

We supply those hard to find parts for the home builder.
Delrin insulators $12/100. Plated keepers $4/100. Stainless $10/100.
Add $6 UPS, $11 for single or pair of Antennas.
$8 west of Mississippi
PA residents add 6% state sales tax

RUTLAND ARRAYS
1703 Warren St. • New Cumberland, PA 17070
(717) 774-5298 7-10 PM EST

111

flea market

RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance.** No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

TEST EQUIPMENT WANTED. Don't wait ... we'll pay cash for LATF, MOD'EL, HP, Tek, etc. Call Glenn, N7EPK, at SKAGITRONICS CO. (800) 356 TRON.

MOTOROLA T45 RTA 860 MHz Trunking $450. Several H23, H33, HT 220's VHF low split $100 each. Scott (801) 224-3783.

MACINTOSH SATELLITE Tracking and Propagation Software. MacTrak™ displays graphic maps (rectangular, polar, great circle), views from space, schedules, windows. Also tracks Sun and Moon. Compatible with KLM/MIRAGE rotor interface. Shows gray line, sunrise/sunset, bearing/distance, MUF vs time, areas of world "open". SASE for info or $49.95 from R. Stegemeyer, PO Box 1590, Port Orchard, WA 98366.

CUSTOM EMBROIDERED EMBLEMS. & Enameled Pins, your design, excellent quality, low prices, free booklet. A.T. PATCH CO, Box 682 Dept 19, Littleton, NH 03561, (603) 444 3423.

BM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

SELL: AEA PK64A/HFM packet $175. ICOM IC 27A 25W, 2m Xcvr $525. Hallicrafters SX115 Receiver $250. Spectrum Communications 450 2m repeater circuit boards TX/RX $50 each and RF power amplifiers $35 each. VHF Engineering ID $25 and COR $10. Radio Shack Color 3 Computer with RS 232 interface $150. ICOM 251A 2m, 10W multimode Xcvr $300. Floyd Chowning, K5LA, 5637 Prince Edward Avenue, El Paso, Texas 79924. (915) 751 6204.

HAMLOG COMPUTER PROGRAMS. 17 modules auto logs, sorts 7 band WAS/DXCC. Full features. Apple $19.95, IBM or CP/M $24.95. KA1AWH, POB 2015, Peabody, MA 01960.

DIGITAL AUTOMATIC DISPLAYS. All Radios. GRAND SYSTEMS, POB 2171, Blaine, Washington 98230.

CHASSIS & CABINTS KITS. SASE. K3IWK, 5120 Harmony Grove Rd, Dover, PA 17315.

VISA MasterCard
CHARGE
YOUR CLASSIFIED ADS
to your MC or VISA, write or call
HAM RADIO MAGAZINE
Greenville, NH 03048
(603) 878-1441

GIANT POWERSTAT Variable Transformer. 240V input 28 Amps. 0-280V output, 7.8KVA $145. plus ship. Joseph Cohen, 200 Woodside, Winthrop, MA 02152 (617) 846-6312.

COMMODORE/AMIGA CUSTOM CHIPS FOR C64/128 Computer/peripherals at low prices. 24 hour delivery. #6510- $9.95, #6526- $9.95, #6567- $14.75, #6581- $12.85, PLA $12.50, 901 ROMS at $10.95 each and many others, including Amiga..."The COMMODORE DIAGNOSTICIAN". A complete diagnostic reference chart for fixing Commodore computers, etc. An absolute must for those who want to fix their own computers and save money and downtime. $6.95 plus $1.00 postage... COMMODORE REPAIR. We are the largest/oldest Authorized Service Center in the country. (eg. C64- $39.95) (We ship worldwide). Heavy duty Power Supply for C64- $27.95 plus UPS. Send for complete chips/parts catalog...VISA/MC...Kasara, Inc, 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-642-7634, 800-248-2983 (outside NY) or 914-356-3131.

WANT COLLINS KWM 2/A and accessories. Also looking for other Collins gear. Call after 4 PM EDST (201) 728-7938.

ANTENNA TUNER WANTED. Heath Model SA 2500 only, non-working acceptable. W2BLL, RD 2, Box 72, Boonton, NJ 07005.

WANTED RECEIVERS. (ICOM: IC-745, IC R7000, Bearcat DX-1000). Scopes and Monitors: Heath: EVW-3 imp scope, SB-620 spect. analyzer, SB-610 monitor. Tektronix: 502A, 544, 546, 547, 549, 556; a relatively new 5 MHz to 10 MHz scope, single channel, do not need time delay; a 500 MHz to 1 GHz scope without the use of sampling. Scope Plug In's: Tektronix. I can use most of the 1 ser. and letter series plug in's, including the spectrum analyzer plug in's, (1L5, 1L10, 1L20, 1L30, 1L40) for the 530-, 540-, 550- series main frame. I have a special need for the Type "T" time base plug in. POWER SUPPLIES: Tektronix, type 127, 132, 133. SIGNAL GENERATOR: Hewlett Packard: 606B or 606A, 608F, 608C, 608E, 612A or 610B, 614A, 616B or 616A. FUNCT & SWEEP GEN: Heath: EU-81A, IG-1271, IG-1273, IG-52, IG-1275. NOISE GEN: For the 5 hz to 2 GHz range. STEREO AMPS: Heath: AA-2004, AA-15, AA-1506, AA-1640, AA-2005A, AA-29, AA-1515, AA-1219. POWER SUPPLIES: Heath: IP-17 or IPW-17 or IP17A, IP-2700, IP-2701, IP-28, IP-2718, IP-15, IP-18, IP-2715, IP-12. FILTERS: Receiver audio output filters - tunable; woodpecker noise blanker. PREAMPS: Receiver RF preamps - tunable. WATT METER: B&W 334A dummy load watt meter. VIDEO: Video cameras as used in closed circuit TV. CAR RADIO MOUNT: IIX Equipment Ltd: Mobile radio mount MM1007 or MM10013. ANTENNAS: Wide band scanning antennas for 10 kHz to 2 GHz. Write to: J.L. Courtney, PO Box 391, Canal Winchester, OH 43110.

CALL SIGN BADGES: Custom license plate holders. Personal, distinctive. Club discounts. SASE. WB3GND, Box 750, Clinton, MD 20735. (301) 248-7307.

FOR SALE: Kenwood TS-820S, digital display. Excellent condition, very clean. $475. Matt, WA1HRE, (203) 693-0468.

PROFESSIONAL QUALITY DTMF Decoder and Select Call System, by Vince Yakamavich, AA4MY, see Feb QST Magazine for details. Blank board #152-PCB only $17.95. Kit of Parts including board, #152-KIT only $69.95. Assembled and tested board #152-ASY only $99.95. Add $2.50 per order S/H. A & A ENGINEERING, 2521 W. LaPalma, Unit K, Anaheim, CA 92801. (714) 952-2114.

ANALOG AND RF CONSULTING for the San Francisco Bay area. Commercial and military circuits and systems. James Long, Ph.D., N6YB (408) 733-8329.

WANTED: Klystron tubes especially 2911; Magnatrons, also 304TL, 6012, 810 and 5CX1500A. All types of sockets for transmitting tubes. Harold Bramstedt, 6104 Egg Lk Rd, Hugo, MN 55038. (612) 429-9397.

UHF PARTS. GaAs fets, mimics, chip caps, trimmer caps, and other builder parts. MGF 1402 @$14.00. MFG 1302 @$10.00. .8-10pf Trimtronics trimmer @$3.75. Porcelain chip caps @$1.75. Orders add $1.00 p + h. SASE for complete list. MICROWAVE COMPONENTS, 11216 Cape Cod, Taylor, MI 48180.

JENNINGS UCS-300-7.5 KV variable vacuum capacitor $135. RJ1A/HC 1 vacuum relay $75, RJ2C $140. Cardwell 2100pF 3 KV variable capacitor $45. Eimac 3CX1200A7 $375, 4CX3,000A $675, 4CX5,000A $950. SK-2210/SK-2216 $85. Centralab 858-1000pF $5 ea. (All new). A. Emerald, 8956 Swallow, Frn Vly, CA 92708 (714) 962-5940.

MACKET: Macintosh packet program, $39.95. For details write to S. HINE SOFTWARE, POB 6037, State College, PA 16801.

PHOTOVOLTAIC PANELS. Lowest prices on Sovonics, Arco panels. From 1 watt to 50. Send $1 for price specs and data sheets. Michael Bryce, 2225 Mayflower, Massillon, Ohio 44646.

RTTY JOURNAL—Now in our 36th year. Read about RTTY, AMTOR, PACKET, MSO'S, RTTY CONTESTING, RTTY DX and much more. Year's subscription to RTTY JOURNAL $10.00, foreign slightly higher. Order from: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1 3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

MARCO: Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc)

invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224 (213) 774-1255

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC, ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

WASHINGTON: June 4 and 5. The Apple City Radio Club's Hamfest, Rocky Reach Dam, 7 miles north of Wenatchee, Hwy 97. Saturday license exams. Free camping and RV spaces. Advance registration $4.00 to Bob Lathrop, K7EVL, 919 N. Wood ward, Wenatchee, WA 98801.

MICHIGAN: June 11. The 14th annual Hamfest sponsored by the Central Michigan Amateur Repeater Association (CMARA), Midland Community Center, Midland, 8 AM to 1 PM. Donation $3. New/used Amateur electronics and computer equipment. License exams. Dealers welcome. Talk in on 147.60/000, Midland. For more information please SASE to CMARA Hamfest, PO Box 67, Midland, MI 48640. (517) 631-9228 evenings and weekends.

NORTH CAROLINA: June 11. Winston-Salem Hamfest & Computer, Electronics Fair '88. Sponsored by the Forsyth ARC. Dixie Classic Fairgrounds. FCC exams, walk-ins welcome. Free parking, convenient lodging, indoor dealers, large flea market tailgating area. For dealer information write Forsyth ARC, Hamfest Committee, PO Box 11361, Winston-Salem, NC 27116.

ILLINOIS: June 12. The 31st Annual Hamfest sponsored by the Six Meter Club of Chicago, Santa Fe Park, 91st and Wolf Road, Willow Springs. Advance registration $3.00. At the gate $4.00. Large Swappers Row, Pavillion Displays, AFMARS meeting, plenty of parking, picnic grounds. No overnight camping. Advance tickets from Mike Corbett, K9ENZ, 606 South Fenton Avenue, romeoville, IL 60441 or any Club member. Talk in on K9ONA 146.52 or K9ONA/R 37-97.

QUEENS, NEW YORK: June 12. The Hall of Science ARC Hamfest, NY Hall of Science Parking Lot, Flushing Meadow Park, 47th 111 Street, Queens, 9 AM to 3 PM. Amateur Radio exhibit station. Tune up clinic, films. Buyers $3.00. Sellers $5.00 per space. Talk in on 144.300 simplex link 223.600 rep and 44.225 rep. For further information call Steve Greenbaum, WB2KDG (718) 898-5599 or Anne Schiffman, WB2YXB (718) 343-0172 evenings.

MASSACHUSETTS: June 12. SEMARA Hamfest sponsored by the SE Massachusetts ARA, South Dartmouth, 9 AM to 5 PM. Admission Free. Dealers $8.00 advance, Door $10. VE exams appointment only "Nepra" Packet Workshop. Tailgating. Talk in on 147.000 and .6 for Hamfest and 145.4900 .6 for back up. For VE exams and Hamfest info SASE to Pete Kerbs, N1EXA, PO Box 9187, North Dartmouth, MA 02747.

KENTUCKY: June 12. "HAM-O-RAMA 88" sponsored by the Northern Kentuck ARC, Erlanger KY Lions Park. Admission $4.00 advance; $5.00 at the door. Children under 13 free. ARRL, Packet and Emergency Forums. Indoor exhibit area, $15.00 per space. Large outdoor flea market, $4.00 per space. Setup 6 AM. General admission 8 AM. Food and refreshments available. Talk in 147.855- 255 and 147.975+ 375. For more information or advance registration contact WA4BHM, c/o NKARC, PO Box 281, Florence, KY 41042. (606) 371-8545.

NEW JERSEY: June 18. The Raritan Valley Radio Club's 17th annual Hamfest, Columbia Park, Dunellen. Gates open 8 AM. Lookers $4.00 donation. Spouse and kids free. Sellers $6.00 one space, $12.00 multiples. Bring your own tables. Talk in on club repeater W2OW R 146.025- .625 and 146.52 simplex. For information call Dave, KA2TSM (201) 763-4849 or John, WA2C (201) 968-5070 or any club member.

MICHIGAN: June 18. The Independent Repeater Association is sponsoring its annual Hamfest, National Guard Armory, 44th Street, 1-2 mile west of US 131, Grand Rapids. 8 AM to 4 PM. Dealer setup 6 AM. Free reserved tables for dealers and sellers. Talk in on 147.165/.165 147.765/.765. For table reservations: Independent Repeater Association, 562 92nd Street SE, Byron Center, MI 49315 (616) 455-3915.

CALIFORNIA: June 19. The Satellite ARC's annual Father's Day Swapfest, Union Oil Company New Love Picnic Grounds south of Santa Maria on US 101. Free Admission. Starts 9 AM. Bar-B-Que served at 1 PM. Tickets: Adults $6.50, children 6 to 12 $3.50, under 6 free. Swap tables available. Talk in on 145.14 repeater. Simplex 146.52. For tickets and information Hank Konczak, W6PME, Santa Maria Swapfest, 917 Anthony Way, Lompoc, CA 93436 (805) 736-1761.

MARYLAND: June 19. The Frederick ARC will hold its 11th annual Hamfest, Frederick County Fairgrounds. 8 AM to 4 PM. Admission $3.0 Tailgaters +$2.00 extra. Exhibitors tables $10 first, $5 each extra. Setup 8 PM June 18. For information write Dave Durkovic N3BKD, 7128 Limestone Lane, Middletown, MD 21769.

PENNSYLVANIA: July 4. The Harrisburg Radio Amateur Club is sponsoring a Hamfest, Bressler Picnic Grounds, 8 AM. Vendors 7 AM. Admission $3.00 at gate. Tailgating $1.00 per site. Pavillion tables $5.00 each. Campground, motels and restaurants nearby. Contact Dave Dorner, KC3MG, 131 Livingston St, Swatara, PA 17113. Phone (717) 939-4957.

WISCONSIN: July 9. The South Milwaukee ARC will hold its annual SWAPFEST, American Legion Post 434, 9327 South Shepard Avenue, Oak Creek. 7 AM to 3 PM. Admission $3.00. Free overnite camping available. Picnic area. The Badger Exams group will conduct exams during the day. Talk in on 146.580 simplex. For more details, including a map write The South Milwaukee ARC, PO Box 102, South Milwaukee, WI 53172-0102.

INDIANA: July 9 and 10. The 18th annual State ARRL Convention and Hamfest, Marion County Fairgrounds, Indianapolis. Gates open 6 AM both days. Gate fee $5.00. Under 12 free. Dealers, electronic flea market, homebrew, tech and ARRL forums. Non-ham activities. Free hookup and camping, food available on grounds. Nearby motels and restaurants. For information Flea Market Space (317) 356-4451, Commercial (317) 745-6389.

PENNSYLVANIA: July 10. North Hills ARC's 3rd annual Ham fest, Northland Public Library, 300 Cumberland Road, Pittsburgh. 8 AM to 4 PM. Free admission. Free dealer and flea market space. VEC exams. ARRL table. Refreshments. HANDICAP AND WHEELCHAIR ACCESSIBLE. For Hamfest info: Bob Ferrey, Jr, N3DOK, 9821 Presidential Drive, Allison Park, PA 15101 (412) 367-2393. VEC info: John Rosenwald, NM3P, 400 Stevens Drive, Pittsburgh, PA 15237 (412) 931-2631.

WEST VIRGINIA: July 17. The 10th annual TSRAC Wheeling Hamfest/Computer Fair, Wheeling Park, 9 AM to 4 PM. WV's Largest Dealers welcome 30,000 square feet under roof, 5 acres flea market. Family activities at Park. Admission $3.00 in advance, $4.00 at door. To reserve space contact: Sandy Williams, KB8AAV, 9 East High St, Flushing, OH 43977; for tickets, TSRAC, Box 240, RD 1, Adena, OH 43901 (614) 546-3930.

OPERATING EVENTS

"Things to do . . ."

June 4 and 5: The Wireless Institute of Northern Ohio (WINO) will be on the air with a special event station to commemorate Ohio Wine Month. Saturday evening 7 to 11 PM EDST, and Sunday 11 AM to 3 PM. The station will be located at a Madison, Ohio winery and will use callsign KO8O. For a special 8x11 certificate send legal sized SASE to KO8O, WINO Weekend, 16418 Briar Hill, Kirtland, Ohio 44094.

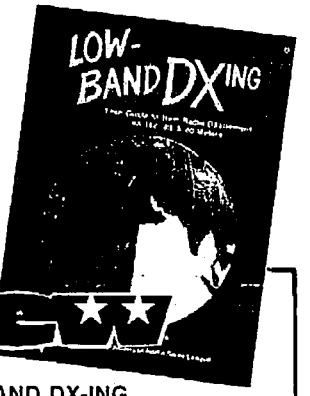
June 19 to 25: K A R S will operate N6WB in conjunction with the 100th Anniversary of the City of Escondido, CA. For a large certificate send QSL and large SASE to Glenn Bodeker, N6WB, 127 Walnut Hills Drive, San Marcos, CA 92069.

June 20 to July 4. The 6th annual Great American Race. Maryland to Boston. KX6B will operate mobile as part of the support team of Car No 73, to commemorate the 80th year since the original New York to Paris Great Race. Operation daily 1900 UTC to 2400 UTC. Lower 25 kHz of 40, 20 and 15m General phone bands. 10m Novice phone. Mobile Packet 145.01 and 2m FM. For QSL SASE to Dick Raley, KX6B, 2610 Camroop Drive, San Jose, CA 95130.

July 4 and 5: The Valley ARA, Staunton, Virginia, will operate N4ICT in conjunction with the Stathi Brothers Happy Birthday USA Celebration. Freqs: Phone 3.855, 7.280 14.250 and 28.375. For the Stathi Brothers certificate send QSL, contact number and 9x12 SASE to Valley ARA, PO Box 666, Staunton, VA 24401.

THE FOUNDATION FOR AMATEUR RADIO, INC plans to award twenty-eight scholarships for academic year 1988-89 to assist licensed Radio Amateurs who plan to pursue a full time course of study beyond high school and are enrolled or have been accepted by an accredited university, college or technical school. For further information write FAR Scholarships, 6903 Rhode Island Avenue, College Park, MD 20740 prior to May 31, 1988.

HAM EXAMS: The MIT 1296 Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes. Novice to Extra. Wednesday JUNE 22, 7 PM, MIT Room 1-190, 77 Mass. Ave. Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 646-1611. Exam fee $4.50. Bring a copy of your current license and any two forms of picture ID and a completed form 610 available from the FCC or Quincy, MA (617) 770-4023.



LOW BAND DX-ING COMPUTER PROGRAMS

by John Devoldere, ON4UN, for Apple IIe/c, MS-DOS, Commodore C-128 Apple Macintosh and Kaypro CPM Computers

Here's a collection of 30 super programs written by ON4UN. Just about every interest or need is covered—from antenna design and optimization to general operating programs. Antenna programs include: shunt and series input L network design, feedline transformer, shunt network design, SWR calculation, plus 11 more! General Ham programs include: sunrise/sunset, great circle distances, grayline, vertical antenna design program, sunrise calendar plus 9 more! Phew. When you sit down to use these programs you'll be amazed at what you have. The best value in computer software available today. 1986.

UN-Apple IIe/IIc	$39.95 ea.
UN-MS (MS-DOS)	$39.95 ea.
UN-CPM/Kaypro	$39.95 ea.
UN-C-128 (COMMODORE)	$39.95 ea.
UN-MAC (MACINTOSH)	$49.95

LOW BAND DX'ING

by John Devoldere ON4UN

Now Available! The new, 2nd edition of the definitive book on Low Band DX'ing. Based upon years of practical on-the-air experience, learn the secrets of how ON4UN has been so successful on the low bands. Extensive coverage is given to transmit and receive antennas with clear concise explanations and plenty of illustrations—dipoles, inverted V's, slopers, phased arrays and Beverages—they're all in this book. Also covered: propagation, transmitters, receivers, operating, software and an extensive Low Band bibliography. Going to be a best seller! Get yours today. 1987 2nd Edition 200 pages.

AR-UN Softbound $9.95

BUY'EM BOTH SPECIAL OFFER

Book & Software Reg. $49.90 ($59.90 for Mac)

Just $44.90 ($54.90 for Mac)

- UN-SO (specify computer) $44.90
- UN-MSO Macintosh Special $54.90

SAVE $5

Please enclose $3.50 shipping & handling

ham radio BOOKSTORE

GREENVILLE, NH 03048 603-878-1441



ELMER's NOTEBOOK

Tom McMullen, W1SL

"Q" signals

There are times when we are reminded that not everyone is familiar or experienced in the language of Amateur Radio. I was following my usual practice of listening to the activity on a local repeater while on my way to work one morning, and encountered a lively discussion on the meaning of a "Q" signal.

The signal in question was "QRU," and each Amateur knew part of the answer and thought that the other was incorrect. I resisted the temptation to break in and enlighten them about the "true meaning and proper use," but instead waited to see what developed. Sure enough, the next morning, the pair got together again; one had looked it up and was now fully informed. He surprised the other Amateur by stating that they were both on the right track, but needed the whole story. As with most Q signals, QRU can be either a question or a statement. When followed by a question mark, it (naturally) becomes a question. Without the question mark, it is a statement or an answer to a question. The discussion and follow-up not only educated the two Amateurs directly involved, but was also helpful to the many ears tuned to that repeater on those two days. Further, the incident triggered a thought that I'm putting to use here – how many other Q signals are unknown or misunderstood by a large number of Amateurs?

why Q signals?

Everyone uses Q signals. Old-timers cringe when hearing Q signals used in voice communications. Their theory is that such signals were invented for CW use, and if you are talking, you should say the phrase instead of the abbreviation.

There was a time when, deeply involved in traffic handling on several CW nets around the country, I agreed with that philosophy. However, after several years of exposure to the voice (and digital) world, I can see the merits of using Q signals wherever they apply, on any mode of communications.

Q signals, and their early companions, "Z" signals, were developed as short-cuts in message-handling procedures in marine and commercial radio circuits. It certainly was easier and quicker for an operator to send "QRU?" instead of "Do you have any messages for me?" The answer, equally shortened, would be either "QRU" (I have nothing for you), or "QTC" (I have messages for you). Before you old-time traffic handlers jump on me, yes, I've tweaked the phrase a bit. QTC really stands for "I have ... telegrams for you," but Amateurs are not in the business of sending telegrams. Anyway, the short Q signal reduced the amount of key-pounding, and to a busy commercial operator, this was a blessing. Amateurs, too, realized the advantage in both time and clarity in using abbreviations and operating signals, and adapted many of them to fit their operations. The "Z" signals served the same purpose in many commercial circuits, but for some reason never caught on with the Amateur fraternity – perhaps because ARRL (American Radio Relay League) publications listed and explained the use of Q signals. Also, it has been rumored that Z signals were proprietary to some network or service, but I've not been able to find a reference that proves this.

voice and digital useage

Everyone uses Q signals on voice operation from time to time. The old

Table 1. Common Amateur Q signals

QRM	Is there interference on the frequency?	There is interference on the frequency
QRN	Is atmospheric noise (static) bothering you?	Atmospheric noise (static) is bothering me.
QRP	Shall I reduce power? (Seldom used by Amateurs as a question.)	Reduce power (Most often used as a statement, as in "I am running QRP here" meaning the power is only a few watts.)
QRS	Shall I send slower?	Send slower.
QRT	Shall I stop sending?	Stop sending. (Usually used to mean the station is shutting down for the moment, as in "I'm going QRT for now.")
QRU	Do you have anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready.
QRX	Shall I wait?	Wait (most often used as in "QRX 5 minutes.")
QRZ	Who is calling? (This is not a substitue for "CQ".)	....is calling you. (Amateurs seldom use QRZ as a reply.)
QSB	Does my signal strength vary?	Your signal strength varies.
QSL	Do you acknowledge?	I acknowledge.
QSO	Are you in contact with .....? (Amateurs seldom use QSO as a query.)	I am in contact with, or, I have made contact with .....(More often used in referring to a contact between two Amateurs, as in "Thanks for the QSO, and 73 to you.")
QSY	Shall we change frequency	Let's change frequency .....
QTH	What is your location?	My location is .....

standard "QSL?" is used to mean several things: "Do you copy?", "Did you copy?", "Do you understand?", and so forth. The answering statement, "QSL" applies to all these questions and more.

When conditions are good, and the signals are "arm-chair copy" between the two stations, there's really no justification for using a voice Q signal, but habits don't get turned on or off according to band conditions. When conditions are poor, or there is abundant interference (there it is again — the Q signal QRM applies), certainly the letter Q sets the listener up to expect two more letters that are pertinent to the situation, and it might be easier to understand "QSY up 3" than "Let's move up 3 kilohertz".

In digital communications, the need is not so much for overcoming interference or weak-signal conditions — packet and AMTOR systems handle that pretty well — but rather a way to reduce the keystrokes at the sending station. Not all packet and RTTY enthusiasts are expert typists, and a few 3-stroke Q signals that can take the place of a whole line of text are a blessing to both sender and receiver. (How often I've stared at a blank screen wondering if something was not working right, only to find the operator at the other end was "one-finger typing" the message.)

In summary, Q signals are both useful and permissible in any mode today. It will help Novices and higher-class licensees to feel more at home on the air if they know what Q signals to use and how to use them. **Table 1** lists the most common signals in both their question and answer form. This is by no means a complete list — some, like "QTE?" (What is my true bearing in relation to you?") would probably be hard to understand and elicit a "HUH?" (which, fortunately, needs no Q signal).

I have modified the original meaning of many of these signals a bit, to make them more compatible with current Amateur Radio usage. The original Q signals were developed for commercial and aircraft use, and the language was either more stilted or directly applicable to a specific situation. As they are wont to do, Amateurs have softened the language and slanted the meaning to fit their needs, which **table 1** reflects.

Amateur traffic nets, both CW and voice, have their own set of Q signals that help to speed up message handling and network management. Many are adaptations of more common signals, with the middle letter replaced by an "N," as in QNU, which is borrowed from QRU, meaning "I have no traffic for the net." Another net signal is QNX, meaning "You are excused from the net." A few minutes spent listening to some of the busier traffic nets on 80-meter CW, 75-meter phone, and a few 2-meter repeaters is a lesson in management and a discipline that gets things done efficiently. When you read the monthly message totals as reported in *QST*, you can see why.

There's another signal — QST. It does not have a question as part of its definition. QST is an alerting call to all Amateurs, indicating that some important information is to follow. It can be used by anyone, and is often heard at the beginning of network announcements and 2-meter repeater emergency-practice sessions. You're undoubtedly familiar with its use before code practice and bulletin transmissions from W1AW, the ARRL Maxim Memorial Station in Newington, Connecticut, and on the cover of their magazine, *QST*, which is the official journal of the American Radio Relay League.

Q signals are a vital and interesting part of Amateur language, useful in conveying information quickly and showing that you are "with it" on the bands. They fit all modes of communication (yes, even Amateur Television — a snowy picture of a card that says QRX 5 in big letters will get its message across), and when both the sender and the receiver know the meaning of "QRM, QSY down 3," things work a lot smoother!

ham radio

JULY 1988 / $2.50

ham radio magazine

ham radio • July 1988



hr

focus
on
communications
technology

annual VHF/UHF issue

ham radio magazine

JULY 1988

volume 21, number 7

T. H. Tenney, Jr., W1NLB
publisher
and editor-in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
production editor

Peggy Tenney, KA1QDG
copy editor

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Rally Dennis, KA1JWF
director of advertising sales

Henry S. Gallup, KA1RYG
advertising sales manager

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Phil Alix, KA1IDP
traffic manager

Hans Evers, PA0CX
cover

ham radio magazine is published monthly by Communications Technology, Inc, Greenville, New Hampshire 03048-0498
Telephone: 603 878 1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail):
one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents; page 89

Microfilm copies are available from University Microfilms, International, Ann Arbor, Michigan 48106
Order publication number 3076

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1988 by Communications Technology, Inc
Title registered at U.S. Patent Office

Second class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *ham radio*
Greenville, New Hampshire 03048-0498

contents

10 sporadic E and 50-MHz translatlantic propagation during 1987
Geoffrey H. Grayer, G3NAQ

38 VHF/UHF world: propagation update — part 3
Joe Reisert, W1JR

56 cheap and dirty 6-meter beam
Glen E. Zook, W5UOJ

60 ham radio techniques: line voltage and power tube life
Bill Orr, W6SAI

64 2-meter monitor
Rodney A. Kreuter, WA3ENK

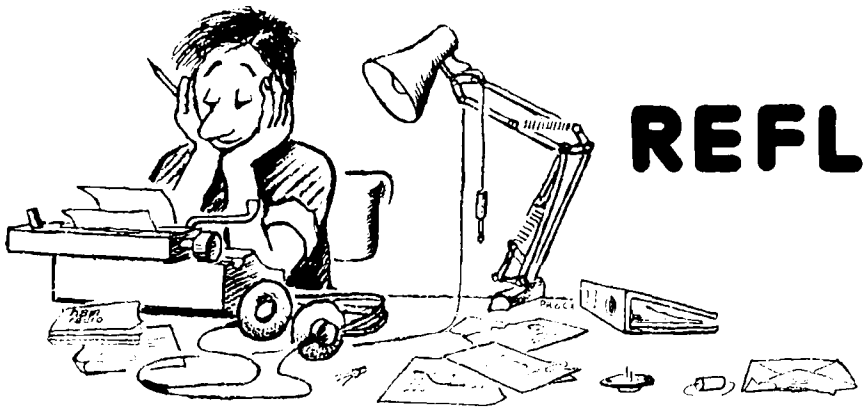
72 practically speaking: non-ideal linear IC amplifiers typical problems and how to solve them
Joe Carr, K4IPV

78 a simple low-cost comb generator frequency calibrator
Larry Martin

90 Elmer's notebook: ten-meter skyware
Tom McMullen, W1SL

The Quad Antenna: part 3 by W4MB will appear in our August issue.

98 advertisers index
9 comments
83 DX forecaster
96 flea market
88 ham mart
71 new products
98 reader service
4 reflections



REFLECTIONS

No doubt about it folks — we've got a mess on our hands.

Recent events in the repeater coordination area would lead a casual observer to believe that chaos is but one small step away. While it may be stretching a point, the reality may not be too far from chaos.

In several regions of the United States, groups who are dissatisfied with current coordinators have formed coordinating bodies of their own. The goals of these new groups may be either well placed or highly questionable, but the confusion they are creating is threatening irreparable harm to the hobby.

Because the events leading up to this situation have already been well reported, I won't go into specifics. I will say, however, that blame needs to be assigned to many. Some would call for the FCC to step in and solve the problem once and for all; in this era of government de-regulation it isn't going to happen. The FCC has neither the budget nor the manpower to step in. Anyway, remember what happened in the '70s when the FCC clamped down on repeaters with all kinds of new regulations and rules. Not too many of us were happy with that situation.

Who else could step in and help solve the problem? The ARRL.

After extensive discussion and planning, Steve Mendelson, WA2DHF, ARRL Hudson Division Director, made a suggestion to the FCC at the Dayton Hamvention FCC Forum that makes the most sense I've heard in a long time. Simply put, this suggestion is for the ARRL to conduct a national referendum of repeater trustees to ascertain which coordination group they support. The referendum results would then be certified to the FCC as a clear mandate of who the preferred regional coordinator is for the majority of repeater trustees. The FCC would then "certify" that group as the sole regional authority for frequency coordination.

I have talked to Mendelson at length and feel that his suggestion has tremendous merit. Mendelson has years of experience in the field of repeaters. He is an ex-president of the New York City Area Coordinating Group and has been actively involved in FM communications for many years.

There are a couple of hurdles that need to be cleared before this plan can be implemented. First, the plan is not a League plan — it is Mendelson's and needs to be proposed to the Board of Directors for their approval at the July Board meeting. Second, the proposal needs to be endorsed by the FCC. Without FCC approval, little will be done to solve the problem. In fact, because of the feelings of some of the participants in this struggle, it could further inflame the situation to the point of complete spectrum anarchy.

If ever there was a reasonable and intelligent suggestion to solve a very serious problem, this is it! I urge you to contact your League Director today and discuss this proposal with him. Notes to ARRL President Larry Price and Dave Sumner wouldn't hurt either. There are currently no alternative ideas; Mendelson's plan is well thought out and offers a good chance to solve the problem before it reaches crisis proportions.

Hopefully, the Board of Directors will agree. We can't afford to wait much longer.

Craig Clark, N1ACH
Assistant Publisher

comments comments

carrier complaint

Dear HR:

I finally got around to thoroughly digging into my copy of your March issue.

Your "Reflections" column hit a very, very sore spot with me (if I may be excused for that old, old cliche). I agree with you that all lids who throw carriers on an occupied frequency should be hung by their thumbs (sorry Bob and Ray). I too have experienced trying to copy a weak DX station with the headset in place on my ears and the audio gain turned way up when some idiot sends me rolling off my chair in pain with an S-9 carrier.

I guess I'm not an aggressive DXer, but I do like to do some of it now and again when the bands are open. More often though, you'll find me chatting with some of my friends about our latest antenna experiments or other projects. It is on many of these occasions when I have had that famous urge-to-kill a few of your DXing friends. It's absolutely infuriating to have some lid, working split with a European on 40 meters, start screaming right on our frequency. Of course we can't inform this dumbell that he is wiping us out because he is listening down below 7100 kHz. Did he ever think to check the frequency he intended to transmit on and/or ask if it was busy? Not on your life. More than once my friends and I have given serious consideration to dropping down on the DX station's transmitting frequency and start up a CW QSO. But we haven't gotten that mad yet...not yet. What is that old saying, "two wrongs never make a right?" So, my DXer friend, next time you get your eardrums blown out by some thoughtless tuner-upper...stop and think. Did you have the same kind of consideration for the guys on 7.229 MHz when you were trying to make a contact with that EA5 operating split the other night?

Next time you get so frustrated you feel compelled to write an editorial on behalf of all of your DXing buddies, slip the shoe on the other foot and see if it fits.

Incidentally, I have prepared charts of settings for both my transmatch and my amplifier. These are kept handy at my operating position, and 99 percent of the time I can go on the air with transmatch and amp without any preliminary tuneup. If there happens to be a little error and the SWR is higher than I would like, I just touch it up while I'm transmitting my side of the QSO. Those amplifier settings were arrived at by tuning into a dummy load, and the transmatch settings were developed by transmitting low power into my antenna on bands which were closed during that part of the day. Once these settings are recorded and stuck on the wall behind my desk I never have to put a carrier on the bands again.

Hell of a fine publication. Enjoy every issue cover to cover. I admit a good many of the articles are over my head but then I would never learn anything if I read only that which I already knew and understood, would I?

Harold P. (Phil) Morgan, WD0P,
ex KAØRUM, Lake Lotawana,
Missouri 64063

remedy for RFI

Dear HR:

Last week one of our local hams, WB6MBT, came to me for help on an RFI problem. Every time he keyed his transmitter, significant amounts of rf appeared at all of his ac outlets. TV reception was impossible. I loaned him a dummy load and suggested he determine if the radiation from his antenna was being coupled into the house wiring. My second suggestion was to check that the neutral ground wire was not connected to his radio chassis. Finally, I suggested that he wind his line cord on a ferrite rod.

Today I received my March copy of *ham radio* and Bill Orr's column fully endorsed my approach.

I will include some comments on this subject extracted from articles in my RFI file.

"Ground Systems," I.L. McNally, *ham radio*, May 1970:

"Do not use the electric utility ground bus as that common impedance will introduce the noise and interference on that ground wire."

"Solving the Problems of RFI," John Labaj, W2YW, *ham radio*, September 1984:

"Better keep all grounds, especially ac and rf grounds separate. The feedthrough of rf power to the ac line will be much greater from a common junction than the ac line would pick up from direct radiation."

"Power Line Grounding: Friend or Foe," WØTHM, *QST*, February 1985:

WØTHM discusses in detail the problems of unbalanced loads in the three wire distribution system. This results in high currents in the neutral wire and an induction field that penetrates throughout the house. Power line transients and power line hash cause serious interference to radio reception if the third wire neutral is connected to the radio chassis.

The first step toward noise reduction is a good earth ground (*ham radio*, May 1980). The second step is to remove the third wire neutral ground connection from the radio chassis. Third, use a good surge and RFI filters in the line supply using a separate earth ground.

The current article on "Radio Grounds" by Bill Orr in the March *ham radio* discusses the use of ferrite rod line filters to reduce the coupling of rf into the house wiring.

It appears that close attention to all of the remedies covered in these articles should go a long way in reducing noise coupling and rf coupling associated with the primary power distribution system.

I.L. McNally, K6WX
Sun City, California 92381

sporadic E and 50-MHz transatlantic propagation during 1987

Examines transatlantic openings on 50 MHz

This article examines transatlantic openings during 1987 from the United Kingdom on the new 50-MHz (6 meter) Amateur band. Data from ionospheric vertical sounders (ionosondes) on both sides of the Atlantic and a correlation with European DX on the same day supports conjecture that propagation is due to multi-hop sporadic E (E_s). The geographical distribution of stations is consistent with the geometry of multiple hops at E layer height and the land distribution. The time behavior of transatlantic openings can be derived from that of European long distance contacts, which in turn is shown to be consistent with E_s on other bands. Thus E_s is now firmly established as being partly or completely responsible for transatlantic propagation on this frequency during solar minimum years.

introduction

In February 1983 the 50-MHz band was released to a number of selected Radio Amateurs in Great Britain, following the termination of Band 1 television transmissions. Since then the band has been made available to both classes of licensees in the United Kingdom (with severe ERP restrictions), and also in certain other European countries. In addition, many Amateurs in countries which still do not allow transmission now have receiving equipment for cross-band contacts. Although the 50-MHz band was available in pre-war Europe, the band has produced many surprises, perhaps due to advances in equipment and an increased number of stations. Recently there has been much discussion about the propagation mechanism responsible for the transatlantic openings which have been unexpectedly frequent during the present minimum in the solar cycle. It was obvious from the reported strength of the signals that propagation was due to a reflection (or more properly, refraction) mode rather than a scatter mode. Transatlantic openings coincided with the months during which intense ionization of the E layer is common and, together with other evidence, this suggested that multiple reflections from E_s were the most likely mechanism. I decided to study a few of these events in detail to see which characteristics could be understood using known E_s phenomenology. Apart from reports by operators of 50-MHz Amateur contacts or reception, data are included from ionosondes at a few MHz, and from observations of Amateur beacons on 28 MHz (10 meter) and of 144-MHz (2 meter) E_s events. A consistent picture is found throughout the spectrum making it possible to predict, simply but accurately, the time of day when a particular long distance path is likely to be open.

E_s: an overview

Sporadic E is the name given to a form of ionization which occurs at E layer heights (100-130 km, occasionally up to 170 km) and exhibits rapid changes in density, position, and height[1]. The characteristics of E_s in the equatorial region, and E_s connected with

By Geoffrey H. Grayer, G3NAQ, "Bagatelle", 3 Southend, Brightwalton, Newbury, Berks RG16 0BE, England

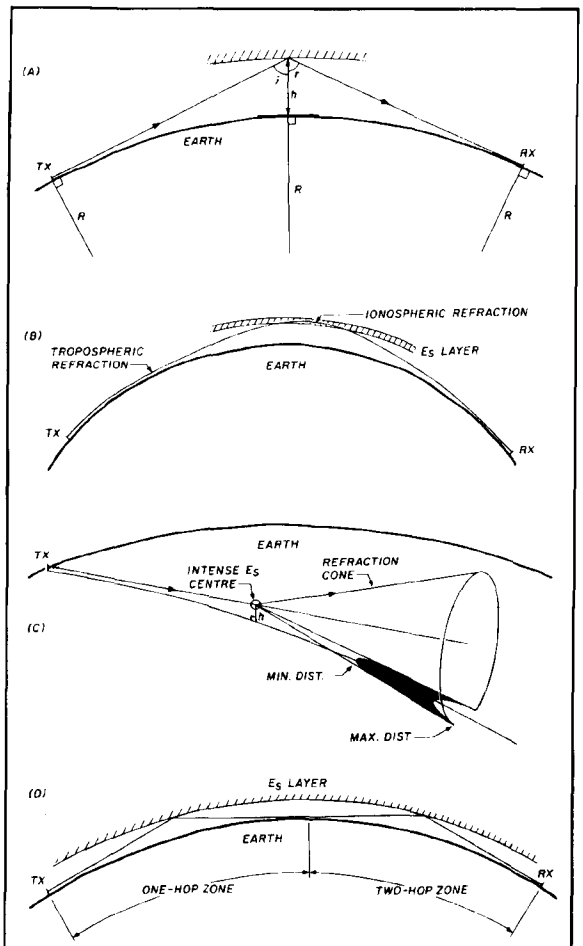


fig. 1. (A) Simple rectilinear single-hop geometry for maximum range; (B) the geometry with atmospheric and ionospheric refraction (exaggerated); (C) an illustration of how the scatter cone produces the characteristic "footprint" on the ground; (D) the chordal hop picture of transatlantic propagation.

auroral activity, differ from temperate zone E_s which is the type referred to here. A temperate zone sporadic E "layer" is characterized by being rather thin in depth (estimates range from a few km to less than 1 km)[2] and uneven in density.[3,4] It is often transparent enough for higher (normal E and F) ionospheric layers to be observed through it by ionosondes probing at vertical incidence. The frequency below which no penetration occurs is known as the *blanketing frequency*, f_bE_s. The lowest frequency which penetrates the E_s layer without any reflection is referred to as the *critical frequency*, f_oE_s. (The suffix "o" refers to the so-called "ordinary" component of the wave.)

The ionization density of the E_s layer is never great enough for the frequency f_o of waves reflected back at vertical incidence to reach 50 MHz. However, as the angle of radio waves meeting the E_s layer moves away from the perpendicular (as is the case for point-to-point contacts) the upper frequency of waves which may be returned to earth increases. The highest reflected frequency f_{max} is normally related to f_o by $f_{max} = f_o/\cos i = f_o \sec i$, where i is the angle between the ray and the normal to the refracting layer (fig. **1**). This relation, sometimes referred to as the *secant law*, is true for a boundary where there is a sudden change of electron density, and is also valid under certain conditions for a horizontally stratified layer[5]. The highest frequencies are reflected when cos i is minimum and i is maximum, corresponding to reflection from an E_s layer on the horizon. In this case the range is near the maximum possible for the height of the reflecting layer; this range is evaluated later. Only if the layer is completely regular will the wave emerging from the layer be at the same angle to the normal — that is, $r = i$. As mentioned above, the layer is in fact usually very uneven in density, and the secant law also implies that regions where the ionization is most concentrated propagate the highest frequencies. These regions can be very small[4], resulting in extremely narrow "beams" of propagation.

Let us imagine what the E_s layer looks like if we could see radio waves at any frequency we chose. At $f < f_b$ (typically a few MHz) we would see the sky covered by a shiny, irregular reflecting surface. Propagation is general over a large area, and multiple hops are possible over the extent of the layer. As f increases through f_b to f_o and above, the patch overhead becomes translucent and then transparent, while the rest becomes increasingly lumpy in appearance. This transparent patch increases in size as the frequency is raised until it spreads to the horizon, but the "sky" remains hazy, as the irregular patches of ionization still scatter *some* of the waves.

Finally, only a few shiny clouds remain on the horizon. At the highest frequencies where there is still evidence of E_s (rarely above 200 MHz), only one or two very small concentrations with an ionization density sufficient to refract the radio wave back to earth will be visible. The E_s no longer looks like a layer, but rather a few small clouds. The waves undergoing maximum deflection from these concentrations of ions form the surface of a cone, filled with waves that are refracted less as they miss the core of ionization. The intersection of this narrow cone with the ground forms the long, narrow wedge-shaped zone of propagation (**fig. 1C**). The width of this track on the ground must subtend less than the cone vertex angle, and in the case of minimum angle to reach ground, it reduces to a line. In practice the refracting clouds are unlikely to be regular in shape, so the "cone" will also be rather irregular. Rays are refracted into a very small solid angle rather than being widely scattered, so signal

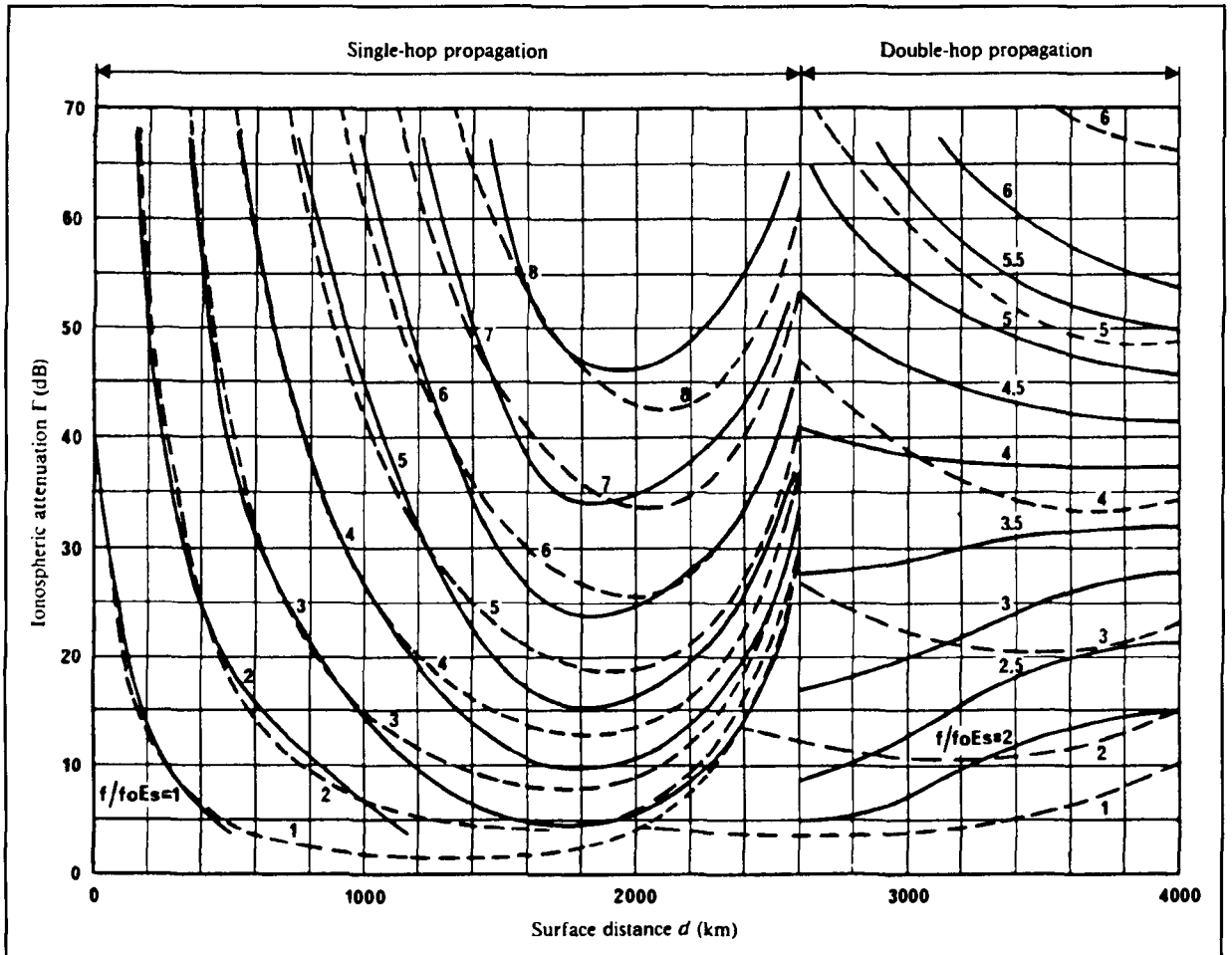


fig. 2. Path loss for E_s propagation as a function of distance with f/f_0 as parameter. Continuous lines are observed values, dotted lines are from an empirical formula[8] (reproduced by permission of ITU).

reduction will be small. Because the grazing angle with the earth is very shallow, a small increase in bending angle will illuminate a long strip on the ground. Since the E_s clouds are not stationary, the area covered on the ground will also move, increasing the extent of the opening. This pattern is typical of the upper end of the E_s spectrum — for example, 144 MHz.

At lower frequencies like 50 MHz this situation will occur more frequently, and sometimes ionization densities will reach levels where the refracted cone grows quite large and skip distance shorter, so that the ground area covered is extensive. The rays in the cone which do not quite reach the ground can go on to encounter another E_s cloud. At 50 MHz there is still a sufficiently high probability of ionization reaching the necessary density for reflection, so an occasional second or third encounter should come as no great surprise. This can be deduced from the pattern of stations heard during suitable E_s conditions throughout the frequency spectrum. The references already quoted also support this scenario.

Now let's consider the maximum critical frequency necessary for E_s propagation, using the simple rectilinear geometry shown in **fig. 1A**. The value of the angle i at maximum range (elevation angle at antennas being zero) is given by

$$i = \sin^{-1}\left(\frac{R_o}{R_o + h}\right) \qquad (1)$$

where R_0 is the radius of the earth, and h is the height of the reflecting layer. At a typical E_s layer height of 115 km, the resulting value of i is 79.2°. The secant law $f_o = f_{max} \cos i$ gives 9.35 MHz as the critical frequency which must be exceeded for 50 MHz to be returned to ground. Because of the irregularity of the E_s layer described above, the secant law is only approximately true in its simple form. Weak propagation does take place by scatter mode above f_{max}, but

there is a rapid increase in signal strength near this frequency[6]. It has been found[7] that a better approximation is $f_{max} = \epsilon f_o \sec i$, where ϵ normally lies between 1.2 and 1.3. For 50-MHz propagation it is probably sufficient that f_o exceeds 7.2 to 7.8 MHz, and the corresponding f_o for 144 MHz is 21 to 22.5 MHz. The observed path loss for sporadic E has been fitted[8] to an empirical formula as a function of f/f_o and distance, see **fig. 2.**

Next consider the maximum theoretical range. From **fig. 1A**, this is given by

$$D_{max} = 2 R_o \cos^{-1}\left(\frac{R_o}{R_o + h}\right) \qquad (2)$$

This expression is a simpler form of that given by Kimbell[9], and predicts the same maximum range of about 2400 km for reflection at a height of 115 km. The calculation assumes: no atmospheric refraction, a point reflection at a sharp ionospheric boundary, and both stations at zero height above ground. Corrections for each of these points will tend to extend the available range, as I will now describe.

In a "standard" troposphere at these frequencies the apparent horizon is 4/3 the distance of the visible horizon. In addition, forward scattering will increase the over-horizon range. In practice, on 144 MHz during summer conditions, a well-equipped station typically has a ground range exceeding 300 km, and low-angle rays go on to hit the ionosphere at some extended point. You would have to trace the ray through the actual atmosphere to find the increase of range obtained in each particular case. Note that the wave will be bent towards a more grazing angle of incidence, hence f_o does not need to be so high for reflection to occur. It is, however, a fact that tropospheric effects are less on 50 MHz than the higher frequency bands.

There is a second effect which tends to extend the range. The ray is returned to earth by refraction in an electron gradient rather than reflection at a surface, and this curved path itself extends the range by the distance

$$d = a \sin i \frac{f}{f_o} \ln\left(\frac{f_o + f \cos i}{f_o - f \cos i}\right) \qquad (3)$$

where a is the "half thickness" of the ionized layer assuming a parabolic distribution of electrons[5], the other quantities having been defined above. Similar penetration effects occur with vertical incidence ionosondes. It can be shown that with some assumptions[10] this extra distance is included in the rectilinear model of **fig. 1A** if one uses the observed or "virtual" height $h' = ct/2$, where t is the time delay measured by the ionosonde and c is the velocity of light. This effect is such that if the true height h = 115 km and the virtual height h' = 125 km, the range is increased by 100 km.

KEEP IT INSIDE

DMQ 5588



- Frequency Range - 13 MHz to 30 MHz
- Power Limit - 1500 Watts P.E.P.
- Diameter - 39 inches
- Wind Survival - 70 + MPH
- Surface Area - < .89 Sq. Ft.
- Antenna Finish - Heat Shrink Tubing
- Coax Connector - PL-259
- Antenna Weight - 4 lbs.
- Magnetic Design Maximum Efficiency
- 100% Copper One Piece Construction
- Military Spec Vacuum Variable Capacitor Rated at 35,000 Volts
- Hi-Q Harmonic Supression
- All Locations - Indoors or Outdoors
- Bi-Directional at 0-20 Degrees TOA
- Omni-Directional at 25-90 Degrees TOA
- High Signal to Noise Ratio
- Direction Feed 52 OHM Coax SWR < 1.5:1
- No Matching Unit, Pretuned Coax, Ground Screen or Radial System

WA2VMO A BELIEVER

WHEN YOU'RE TOLD YOU CAN'T — THE DMQ-5588 SAYS YOU CAN

OPERATION: Apply power to DMQ-5588 and adjust vacuum variable for lowest SWR.

INSTALLATION: DMQ-5588 inside ground floor apartment brick building 100W.

DX CONTACTS MADE BETWEEN 3/88 TO 5/88: 5Z4 P43 PAO TK9 DJ8 GW0 CP5 YS9 ZS6 J37 ZD8 HP9 WP4 IK4 HK6 GM4 I5 EA5 JH1 C6 HK6 IK2 GD4 PJ2 HP4 CE1 5Z4 5T5 KP4 UT4 SP3 CP3 F9 IK3 N81 UA6, UR2 UP1 YT2 UB5 IV3 EA5 TG9 GJ5 ON7 YU1 VO1 DL6 J73 PY8 TI2 LZ1 PY5 OE4 GI0 G4 WP4 KL7

Become a Believer! For more information about this exciting new antenna, call or write DMQ today! Limited time intro offer: $349.50 + Shipping.

221 Slater Boulevard
Staten Island, NY 10305
(718) 979-3505

DMQ TECHNOLOGY

114

COMMANDER II VHF
LINEAR POWER AMPLIFIER



SPECIFICATIONS

Frequency Range – 144-148 MHz
Modes – USB, LSB, RTTY, FM
Power Requirements – 117/234VAC with 234VAC recommended
RF Drive Power – 10-15 Watts Nominal 25 Watts Maximum
RF Output – 15+ DB Gain or over 650 Watts
Input Impedance – 50 OHMS
Output Impedance – 50 OHMS Nominal
Antenna Load – 2:1 Maximum
Harmonic Suppression Down 60DB @ Rated Output
Intermodulation Distortion Down 30 DB Minimum
Weight – 56 lbs.
Cabinet Size – 14¾" x 14¾" x 6"
Tube – 3CX800A7 Ceramic/Metal Triode
Pressurized Chassis Forced Air Cooling

FEATURES

Reduced Ratio (6 to 1) on all Tuning Controls for Smooth and Easy Tuneup.
Front Panel Input Tuning Control Allowing a Higher Circuit "Q" for Excellent Linearity and a Very Low Input VSWR all Across the 2 Meter Band.
A Switched Multimeter for Monitoring Plate Voltage, Plate Current, and Grid Current.
External Coaxial Relay or Sequencer Needed for Transceiver Operation.
UPS Shippable.

MADE IN U.S.A. BY HAMS FOR HAMS
Direct from Manufacturer

112

$988.00 (Coaxial Relay Extra)

Ohio Residents Add Sales Tax. VISA and Mastercards accepted. Prices or specifications subject to change without notice.

COMMAND TECHNOLOGIES, INC.
1117 West High Street, Bryan, Ohio 43506 (419) 636-2721

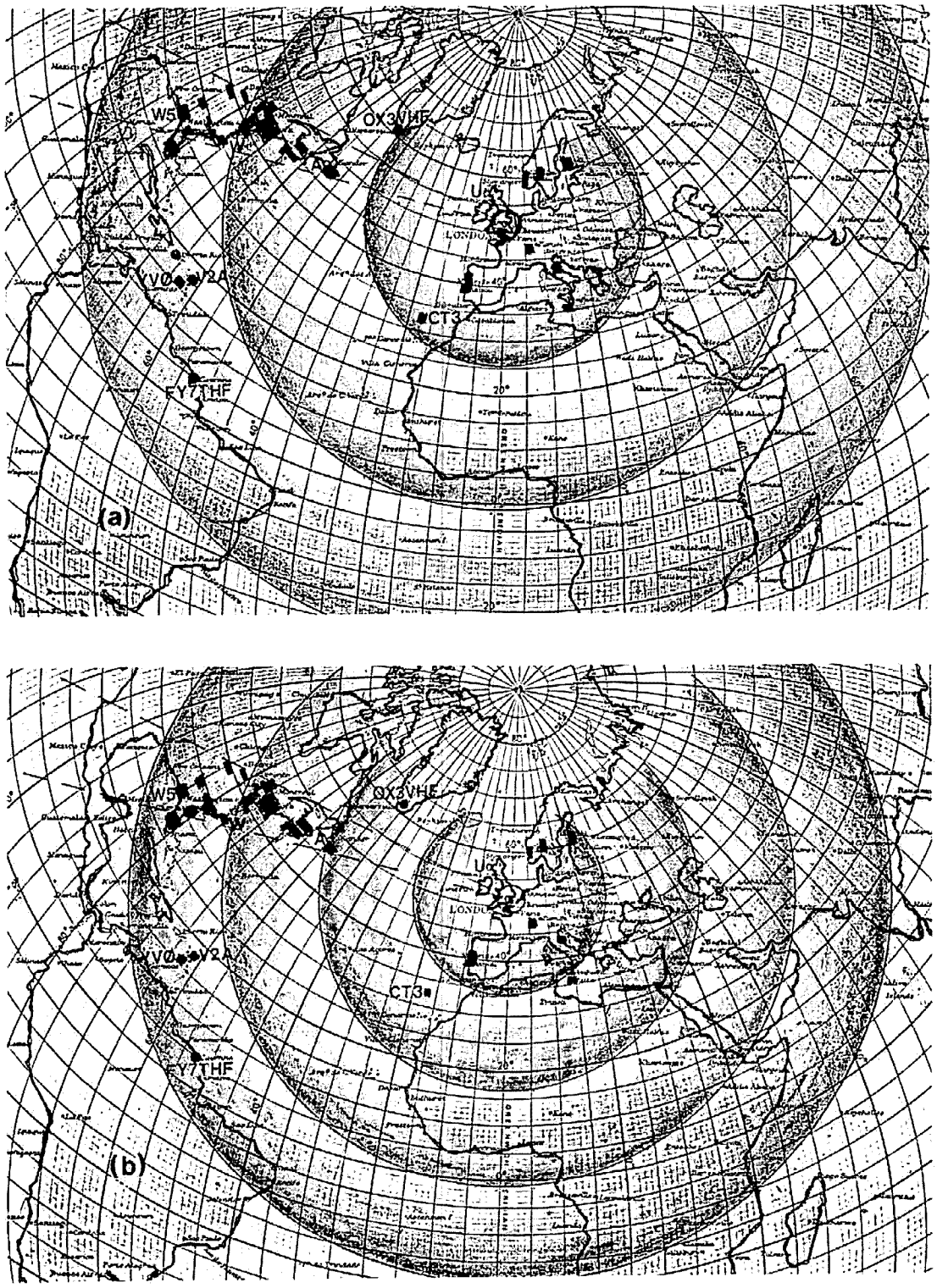


fig. 3. Distribution of 50-MHz propagation from England and Wales (black areas) during 1987 plotted on a Great Circle projection centered on Greenwich. The 50-MHz beacons OX3VHF and FY7THF are indicated, also the ionosondes on Wallops Island (W), Argentia (A), South Uist (U), and Slough (S). The shading shows the areas with highest probability of contact assuming: (a) Double hop transatlantic E_s propagation, (b) Triple hop transatlantic E_s propagation.

Table 1. Summary of principal 50-MHz openings[11] during 1987 used in *fig. 3*. Callsigns and prefixes are in bold. †IARU World Locator System[12].

Date	Start	End	Locators† worked/heard
May 25	1605	1830	IN80,JN36
to	2012	2048	**FY7THF**
May 26	2220	0037	EN90,EM74,EM90,FM09,FM18,FM19,FM25,FN31,FN32,FN42,FN43,FN44, FN53,GN37
Jun 7	1253	1552	FN43,FN44,IN61,JM75,JN53,JN64,JO45,JO65,JO67,KM64
Jun 15	1643	2041	FK97(**V2A**),IN53,IN60,IN61,JN02,KM64,KP01,JN36,JN87
Jun 15	2328	2343	EM94,FM04,FM15
Jun 17	2136	0042	EM70,EM79,FM09,FM18,FM19,FM29,FN20,FN31,FN32,FN42,FN43,FN44,FN53,GN37
Jun 18	1155	1211	EL96,EL97
	1610	1940	IO54,IP62,JN11,JN47,JN58,JN64,JO43,JO45,JO55,JO65,JO67
	2006	2040	FN44,FN74,GP60(**OX3VHF**)
	2134		**FY7THF**
Jun 19	1725		EN86,FM18,FM29,FN20,FN21,FN24,FN25,FN31,FN32,FN34,FN42,FN43, FN44,FN74,
		2002	GN37,**FY7THF**
Jun 21	1714		FM28,FM29,FN12,FN20,FN21,FN24,FN25,FN31,FN32,FN34,
		2200	FN41,FN42,FN43,FN44,FN74,FN84
Jun 24	1451		JM75
	1714	1830	FK85(**YV0**)
	1917	2034	IM59,JN11,JN12
Jul 10	1908	2116	GP60(**OX3VHF**),JP61,KP01
Jul 17	1815		EN81,FN91,FM19,FM29,FN13,FN20,FN21,FN24,FN25,FN29,FN31,FN32,
		2200	FN41,FN42,FN43,FN44,FN51,FN53,FN84,FN86,JO67,JP61
Jul 19	0715	2010	IM12(**CT3**),IM59,JN69,JO28,JO29,JO53,JO59,JO65,JP61
Jul 21	1645	1731	JN13,JN33,JP61
	1829	2250	FM15,FM28,FN20,FN31,FN32,FN41,FN42,FN43,FN44,FN53,FN74,FN84, GN37

Thirdly, stations at both ends of the path will in general have an advantage in height compared with the simple model, which assumes both stations at sea level, and thus a horizon at zero distance! For a height of 100 m, this geometric horizon becomes 35 km, increasing to 50 km at 200 m height. If stations on either end were situated at 200 m ASL with their horizon at sea level, their range (ignoring refraction effects) would be increased by 100 km. There is an effect counteracting this, however; ground reflecton inclines the principal antenna lobes upwards by an angle depending on the radiation pattern, the antenna height, and the nature of the surrounding land.

To summarize, in the situation in **fig. 1B**, it should not be surprising if the maximum observed skip distances exceed that derived from the simple approach of Kimbell[9] by some hundreds of km.

multiple hop E_s

The locations of long distance stations heard or worked in the United Kingdom on 50 MHz during 1987 (**table 1**) are plotted on maps (**figs. 3A** and **3B**) centered on Greenwich, using a projection in which directions and distances are true globally along great circle paths measured from the central region (circled). The locations of the North American stations are shown separately and on a larger scale for a few major openings on **fig. 4**. Note that all times quoted in this article are UTC.

Table 1 and **fig. 4** show that the majority of openings to the United States in 1987 had a similar pattern, most of the stations contacted being in a rather limited area. This is also one of the characteristics of E_s openings on the higher frequencies. The northerly limit is given by the region in which midlatitude E_s is normally found (**fig. 6**), and the southern extent is bounded by the sea. It is assumed that the most distant stations contacted correspond to the limiting case in terms of chordal hops, which do not quite touch the earth between E_s reflections (**fig. 1D**). As many authors[13] have noted, there is no need to invoke a reflection off the sea between ionospheric reflections; this would only decrease range and signal strength.

The outer limits of the zones shown in **fig. 3** are meant to indicate the maximum range normally found from E_s propagation. Obtainable range extends towards the observer with increasing ionization density, but the probability falls rapidly at the same time (indicated by the shading). Unusually intense ionization at one or more of the reflection points will fill in the intermediate areas, but its occurrence will be rarer. Maximum range is statistically the most probable, and chordal hops can occur at densities below that needed for ground-to-ground liaison. The outer zone limits represent the points of nearest approach to the earth for maximum range chordal hops. This does not mean to imply that multi-hop propagation has an intermediate ground reflection.

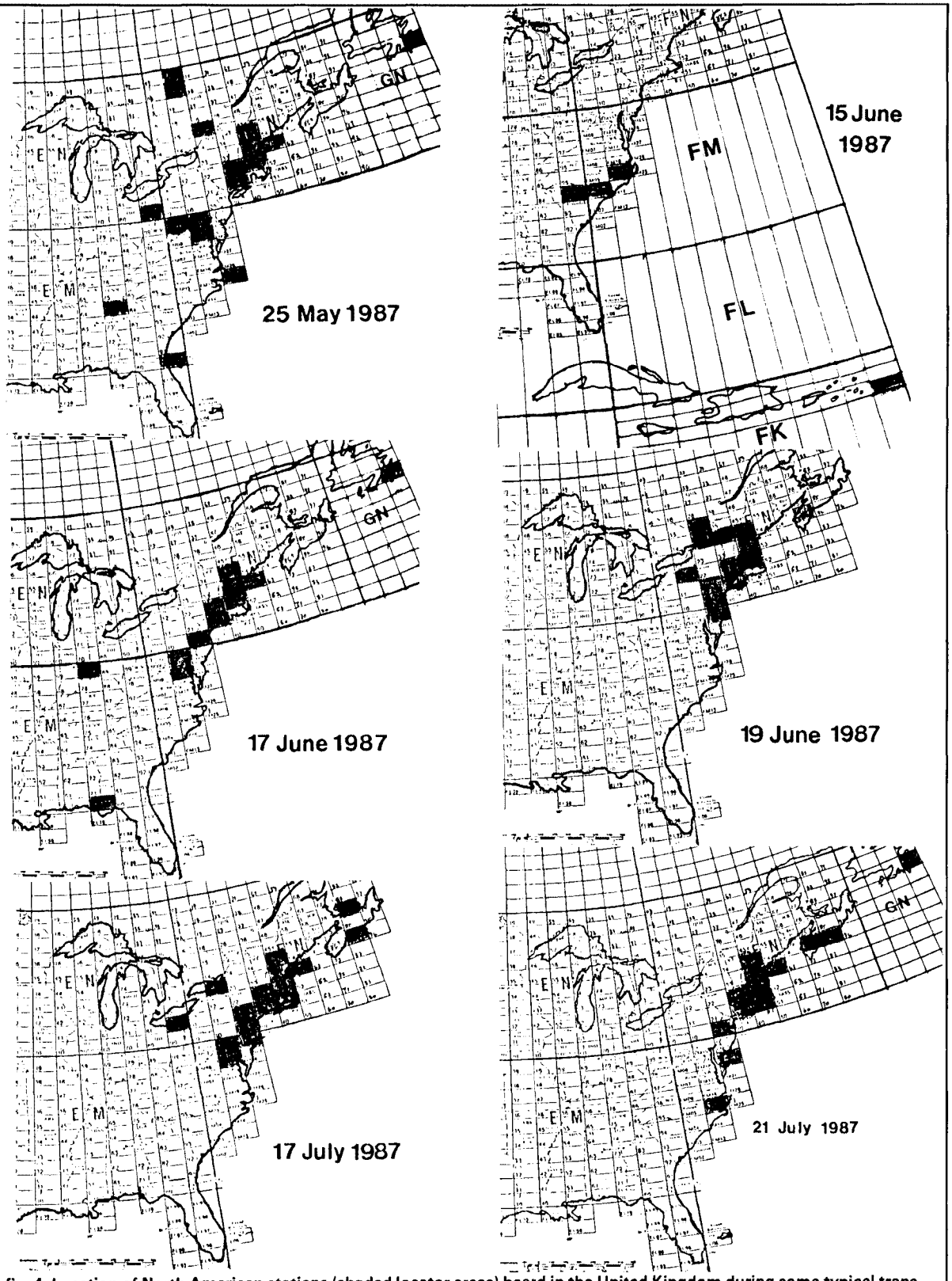


fig. 4. Location of North American stations (shaded locator areas) heard in the United Kingdom during some typical trans-atlantic openings, including those examined in the text.

Figure 3A illustrates two-hop propagation to the main area of North America, corresponding to a maximum skip distance of about 3000 km and a minimum of 2000 km, distances which are credible in view of the preceding discussion. Bands corresponding to one, two, and three hops have been drawn using these limits. E_s contacts at these distances on 144 MHZ are very rare; contacts in the 1500 to 2000 km range are more common. The record distance for an E_s contact from the United Kingdom on 144 MHz is about 3475 km to Cyprus, while the world record E_s distance on 144 MHz is 3865 km from Lebanon to Portugal. These distances seem excessive to be single hop, even taking into consideration the previous arguments, but are consistent with twice the common-hop distance. Note that in each case the countries involved lie in a zone of high incidence of E_s (**fig. 6**), and double-hop propagation becomes more likely. In **fig. 3B** bands are shown corresponding to triple-hop propagation to North America, each hop being between 1350 and 2000 km which match the 144 MHz data well. **Figure 2** shows a minimum in this distance range for $f/f_o <$ 7 — that is, refractive propagation. The European 50-MHz contacts shown in **fig. 3** are also typically within this range.

No firm conclusion can be drawn at this stage as to whether **fig. 3A** or **fig. 3B** is the correct picture, but on balance the evidence suggests the latter. Although the reduced probability of finding a triple rather than a double coincidence of suitable E_s supports the two-hop case, it will be seen below that there are several instances of contacts indicating two hops between 1150 and 1500 km. It should be possible to infer the normal skip distance for multi-hop paths by examining logs of Amateurs in North America, where there are stations along the transcontinental east-west path, unlike across the Atlantic!

estimate of probability

The principal objection to multiple hop E_s being accepted as the mechanism for transatlantic openings may be that the probability of suitable E_s "clouds" correctly positioned is too small. In Europe, this view seems to be based on experience of E_s at 144 MHz, forgetting the much more common propagation on 28 MHz. However, the time for which f_{max} exceeds a certain value decreases very rapidly with frequency. This is illustrated in **fig. 5** — a plot of the number of days during 1976 when a particular value of f_oE was exceeded at the Wallops Island ionosonde. These data were chosen for 1976 (one period previous in the solar cycle) because of the 15-minute sampling rate throughout the year; comparable data for 1987 was unavailable. Two lines are drawn in **fig. 5** showing the relation of f_o to f_{max}, assuming the secant law with

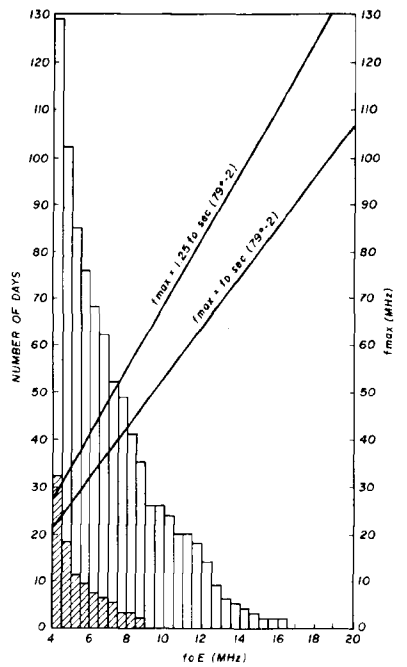


fig. 5. Plot of the number of days during 1976 that Wallops Island ionosonde exceeded a particular frequency. The shaded histogram is for the out-of-season months, *ie* excluding May, June, July, August. The line relates f_{max} to f_o for the simple model discussed in the text.

and without the correction factor $\epsilon = 1.25$. Note that $f_{max} = 50$ MHz is exceeded on 52(26) days, compared with 128(76) days when $f_{max} > 30$ MHz (uncorrected values are given in parentheses). Thus E_s is present at 50 MHz for 35 to 40 percent of the time it is found on 30 MHz.

I must point out the errors in using vertical ionosonde data in this way. A factor has already been introduced to correct the secant law. This factor was justified on account of the irregular nature of the E_s layer. The highest concentrations of ionization seem to be very small in extent, as is evidenced by the extremely limited areas of propagation on 144 MHz, and also by radar observations[4]. If the dimensions (in particular in the vertical direction, which is normally the minimum) become comparable with the wavelength (25 meters at 12 MHz), then an incident wave will be scattered rather than reflected, however concentrated the ionization. These patches may never be detected by ionosondes, providing a good justification for studies of point-to-point communication. In addition, the periods when the highest frequencies are propagated are very fleeting; at a sampling rate of 15 minutes, there is a good probability that these extreme excursions will be missed, either in time or in space.

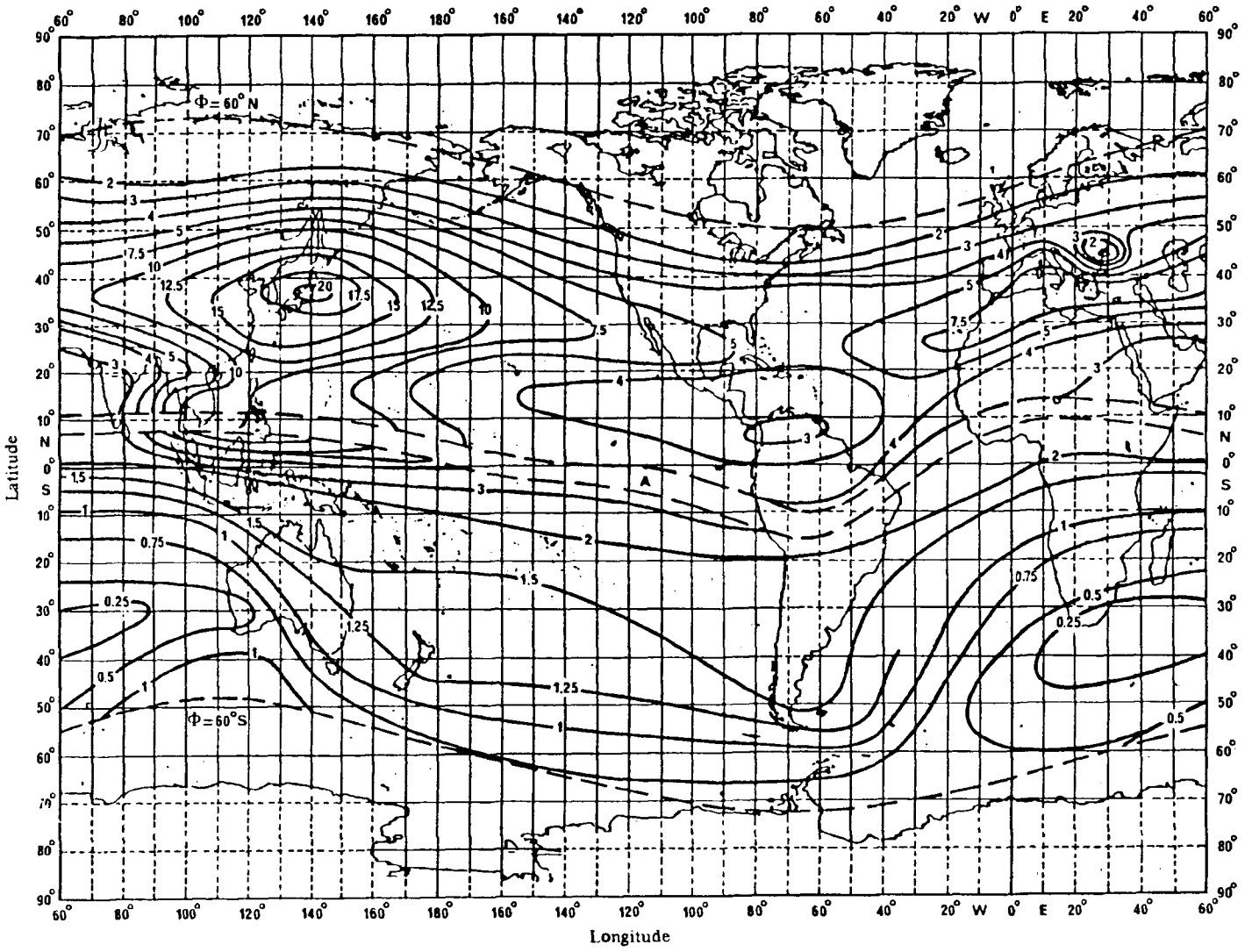


fig. 6. Map showing the percentage of time f_oE_s exceeds 7 MHz in the temperate zones between May and August (Northern Hemisphere) and between November and February (Southern Hemisphere)[8] (reproduced by permission of ITU).

So while the figures above are likely to be good estimates, the data cannot be extrapolated to 144 MHz, where **fig. 5** shows that an f_{max} of 144 MHz was *never* reached! The lack of appreciation of these factors has led a number of commentators in the past to disbelieve Amateur reports of 144 MHz E_s!

Figure 5 was used to estimate the number of days on which 50-MHz propagation by E_s was possible. An estimate of the *total time* this was possible can be made from a CCIR document[8]. This gives for Region A (Europe and North Africa) f_oE_s exceeding 7.5 MHz, corresonding to $f_{max} > 50$ MHz using $\epsilon = 1.25$ for 2.5 percent of the time, or about 46 hours, in the period 0800 to 2300 UTC from May through August. The equivalent value for Region B (North America) is 3.5 percent, or 65 hours. Split between the 52 days on which $f_{max} > 50$ MHz at Wallops Island, as evaluated above, this implies an average opening of more than one hour. From **table 1** it seems that the days when transatlantic communication occurred were those in which the E_s lasted much longer. These graphs unfortunately do not extend beyond $f_oE_s = 12$ MHz, probably for reasons similar to those listed above, so again estimates cannot be made for 144 MHz.

correlation between European and transatlantic propagation

There is no dispute that E_s is the propagation mechanism of 50-MHz contacts made over distances of 1000 to 2000 km during the summer months. From the United Kingdom, these were reported on no less than 40 days out of the 61 in June and July (66 percent). Compare this with the 52 days during 1976 when Wallops island ionosonde suggested that 50-MHz propagation was possible, estimated above from f_o. Transatlantic propagation was reported on 8 of these days (13 percent). The probability of both occurring on the same day if their origins are unrelated (that is, due to different mechanisms) is 66 percent × 13 percent = 8.6 percent, or 5.2 days. In fact, 7 (11 percent) out of 8 of the days when North American stations were heard had earlier produced European contacts. Although the difference of 2 days is hardly significant in a statistical sense, it could become so if this test were extended to months during which E_s occurred less frequently.

ionosonde data at the time of 50-MHz openings

If E_s can be shown to be present on both sides of the Atlantic during transatlantic openings, this would constitute very strong circumstantial evidence for this mode of propagation. Unfortunately the current distribution of active ionosondes is significantly reduced compared with the IGY era. The four active and relevant to this investigation are shown in **fig. 3**. They are located at Slough, southern England; South Uist, Outer Hebrides, Scotland; Argentia near St. John's, Newfoundland; and Wallops Island off the coast of Maryland, United States. A number of openings of special interest are described next.

July 10, 1987

First consider the evidence for E_s propagation into the nearer zones of **fig. 3**. The Greenland 50-MHz beacon OX3VHF, situated just above 60 degrees North in latitude, is above the zone where E_s is prevalent (see **fig. 6**). But on July 10, 1987, this beacon was audible throughout the United Kingdom between 1945 and 2115 UTC (**table 1**), at distances between 2500 and 3000 km. At 2000 UTC the South Uist ionosonde, located near the great circle path (**fig. 3**), shows E_s with $f_o = 10.2$ MHz, amply exceeding the minimum f_o for 50-MHz propagation. An hour earlier it had reached the highest value of f_oE_s recorded at this station during the year, 12.1 MHz (**table 2**). This intense E_s to the north also gave short-skip E_s contacts into Norway and Finland (1140 to 1600 km). Considering the high values of f_o observed, the propagation of OX3VHF is consistent with two rather short hops of 1250 to 1500 km, or one of 2500 to 3000 km (**fig. 3B**).

Table 2. Ionosonde data for July 10, 1987. The f_oE_s in brackets are the monthly median values for that time of day.

	Slough		South Uist	
UTC	f_0E_s MHz	h′ km	f_0E_s MHz	h′ km
1600	3.4(4.7)	110	3.2	105
1700	3.5(4.4)	110	3.2	105
1800	3.0(4.4)	110	3.8	125
1900	3.0(4.3)	115	12.1	120
2000	3.1(4.4)	110	10.2	110
2100	3.7(3.7)	105	8.4	110
2200	3.8(3.8)	110	2.5	120
2300	2.9(3.4)	115		

July 19, 1987

At the southerly end of this arc (there is only sea in between) on July 19, 1987, several stations contacted Madeira (marked CT3 in **fig. 3**) between 1600 and 1836 UTC at distances of 2300 to 2600 km. At the same time many stations were contacted in Portugal, ranging between 800 and 1500 km, so it seems highly probable that two hops of 1150 to 1300 km were responsible. At around 1800 UTC a contact between Norway and Madeira took place, a distance of 2600 km. Since Norwegian stations were audible in the southern United Kingdom at the time, it is possible this was a triple-hop contact. Both the Slough and South Uist ionosondes show E_s present during this

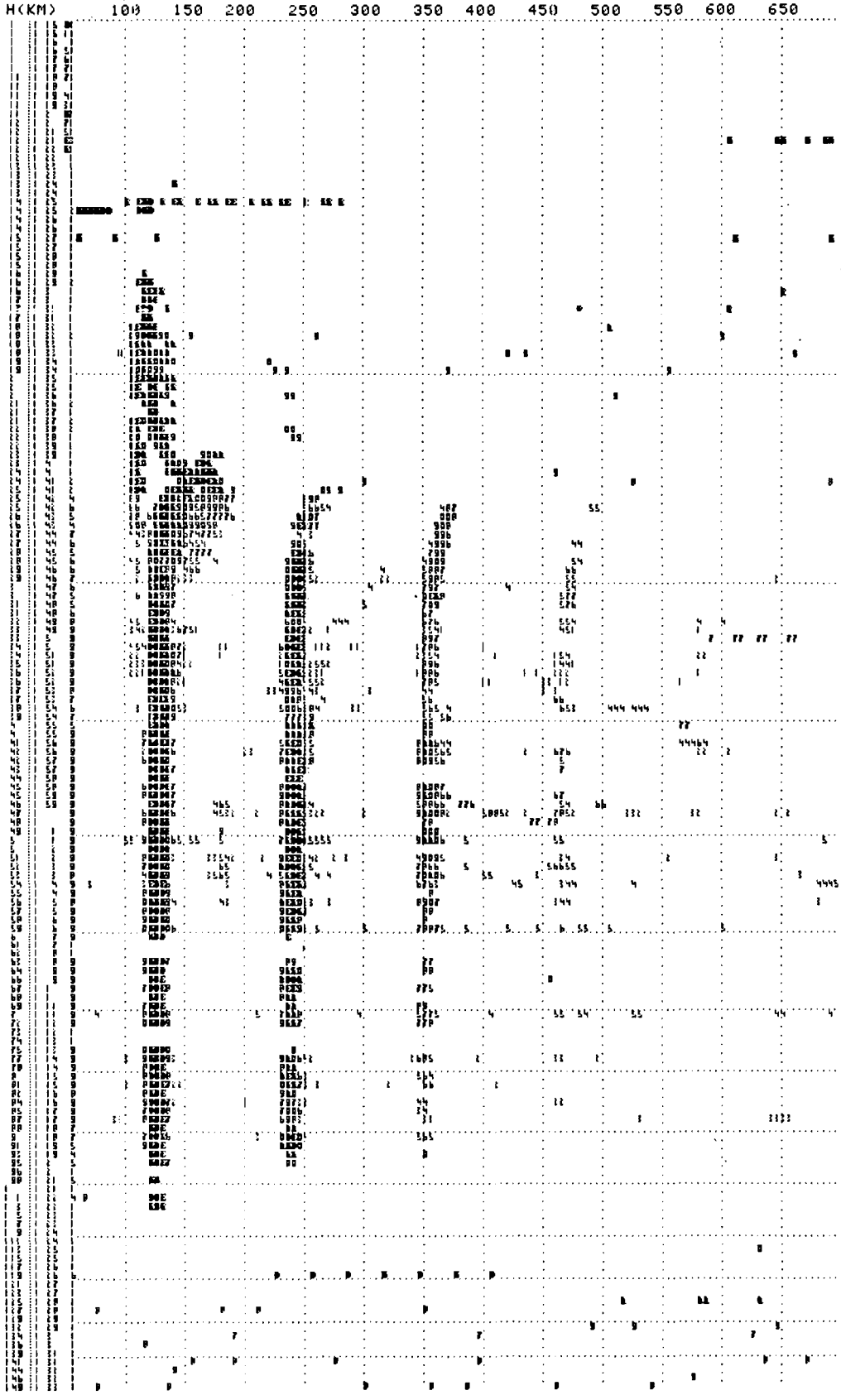


fig. 7. The ionogram recorded at Slough on June 19, 1987 at 1800 UTC. It shows at least four reflections from a blanketing E_s layer at a virtual height of 130 km.

Table 3. Ionosonde data for July 19, 1987.

	Slough		South Uist	
UTC	f_0E_s MHz	h′ km	f_0E_s MHz	h′ km
1500	5.5(5.0)	120	none	
1600	8.5(4.7)	115	4.7	130
1700	5.5(4.4)	120	3.2	105
1800	4.0(4.3)	120	4.5	105
1900	2.8(4.3)	125	3.5	135
2000	5.7(4.4)	115	2.65	180

time (**table 3**), though only one value (that for Slough at 1600 UTC) exceeds the f_0 required for this skip at 50 MHz. Because the ionosonde samples only a very limited area once an hour, small high density clouds may not be observed. Transatlantic propagation was not recorded on either this or the next day, but July 21st produced a long list of North American stations heard in the United Kingdom.

June 19, 1987

Now let's look at the transatlantic opening of June 19, 1987 occurring between approximately 1725 and 2000 UTC (**table 1**). The areas heard in central and southern England and Wales shown in **fig. 4** are typical of other openings shown in the figure. The Slough ionosonde (**table 4**) shows E_s increasing from 1600 UTC, and f_0 exceeding 7.5 MHz sometime between 1700 and 1800 UTC. **Figure 7** shows the appearance of the ionosonde trace at 1800 UTC. The lowest trace represents the first reflection of the E_s layer; the similar ones above are the second, third, and fourth reflections, with an intermediate ground reflection between each one. The apparent heights of these layers were $2h'$, $3h'$, and $4h'$. There was no sign of an F layer, so the E_s layer blanketed up to the highest frequency. By 2000 UTC the E_s was less dense, and had almost disappeared by 2100 UTC. This behavior correlates with the times that transatlantic signals were recorded. Because the first ionospheric reflection takes place in a northerly region of low E_s probability, it might be expected that the presence of E_s in this region determines the path. The ionosonde at Slough, some 1200 km to the east, is the nearest. Unfortunately, the ionosonde at Argentia, Newfoundland, situated near the great circle path, was not operational at this time. But the Wallops Island ionosonde, some 2000 km to the southwest, does show the presence of E_s, though

Table 4. Ionosonde data for June 19, 1987.

	Slough		South Uist	
UTC	f_0E_s MHz	h′ km	f_0E_s MHz	h′ km
1500	5.9(4.0)	120		
1600	3.6(4.1)	150	3.9	165
1700	6.7(5.0)	125	4.0	145
1800	9.9(4.0)	115	5.2	130
1900	10.1(5.0)	115	5.3	125
2000	8.7(3.3)	115	4.6	120
2100	1.6(3.2)	—	8.7	110

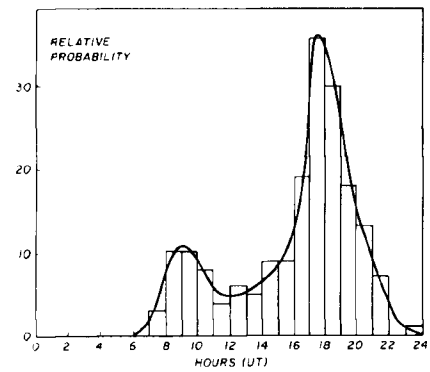


fig. 8. Hours during which European E_s signals were reported on 50 MHz during summer of 1987. The curve is a freehand smoothing.

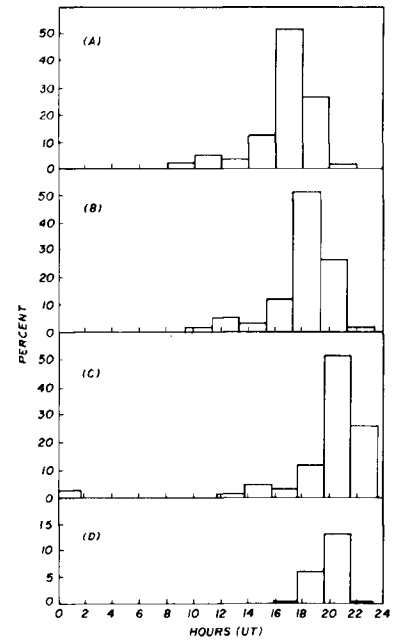


fig. 9. (A) Distribution of 144-MHz E_s openings throughout the day binned in 2-hour intervals[15]; (B) and (C) the same distribution shifted to the position of the two ionospheric reflections on a transatlantic path; (D) the product of (B) and (C).

not reaching particularly high values of f_0 during the opening (**table 4**).

July 17, 1987

The distribution of contacts on July 17, 1987 is much the same (**fig. 4**). This time all three ionosondes show a sporadic E layer at the time of the opening, and the E_s trace again disappears from the Slough data about the time the opening terminated (**table 5**). The critical frequencies recorded are not very high, but see the comments made for July 19th. Note that this opening finished two hours later than that of June 19th, and that the F2 layer was also evident on the ionograms at both Slough and Argentia. This is unlikely to be material for two reasons: the f_0F2 was too low (5.7 MHz at 2200 UTC) and the F2 layer does not show the inhomogeneous structure of E_s, and the area of propagation is similar to the other events. For the F layer to span the range of stations contacted during this opening in a single skip would require (using

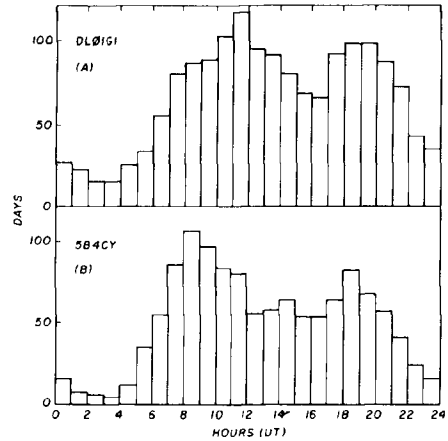


fig. 10. (A) Reception of DLØIGI on 28.205 MHz; (B) reception of 5B4CY on 28.220 MHz, for June, July, and August 1976 and 1977.

Table 5. Ionosonde data for July 17, 1987.

	Slough		Argentia		Wallops Is.	
UT	f_0E_s MHz	h′ km	f_0E_s MHz	h′km	f_0E_s MHz	h′km
1500	none					
1600	5.8	120				
1700	4.4	120				
1800	3.3	120				
1900	2.8	130				
2000	3.1	135	5.1	130	5.4	110
2100	2.8	120	4.2	120	4.2	110
2200	none		4.8	120	5.1	110
2300	none		3.7	120	6.1	110

the formula derived from **fig. 1A**) heights between about 350 and 800 km, and critical frequencies between 15 and 23 MHz — conditions certainly not observed on the ionograms!

diurnal pattern of transatlantic contacts

It has been noted that the daily time distribution for 50-MHz transatlantic E_s contacts looks very different from that of typical European E_s openings[9]. I will show that the two are in fact strongly related. **Figure 8** shows the hourly distribution of 50-MHz European DX during the summer of 1987.

This histogram was constructed by making an entry for each hour during which 6-meter continental European stations were logged by the stations contributing to **table 1**. This means that the same hour can appear several times in the histogram, making calibration in terms of probability difficult. The distribution obtained is typical of that found for E_s. A comparable plot for 144 MHz E_s given by Pasteur[15] is shown in **fig. 9A**. Agreement with **fig. 8** is good for the afternoon peak, while the morning peak occurs earlier on 50 MHz.

This double time structure is also found on the hf bands. **Figures 10A** and **10B** show, for each hour of the day, the number of days that two 28-MHz beacons were observed at Keele, central England[16] during the months of June, July, and August 1976 and 1977, at a similar point in the solar cycle. Continuous observations were made using an automatic recorder. The distances imply that this propagation was either due to E_s or was exceptionally auroral; the latter was excluded on the basis of signal characteristics. Here the morning peak was the dominant one, and occurs somewhat earlier than on the higher bands. Now DLØIGI[17] at 3450 km must be double-hop propagation with the reflection taking place at around 13° and 24° E. Assuming that the pattern of occurrence moves with the sun, you can see that the peaks are shifted about the correct amount and in the correct direction (15° longitude is equivalent to 1 hour). Note also that

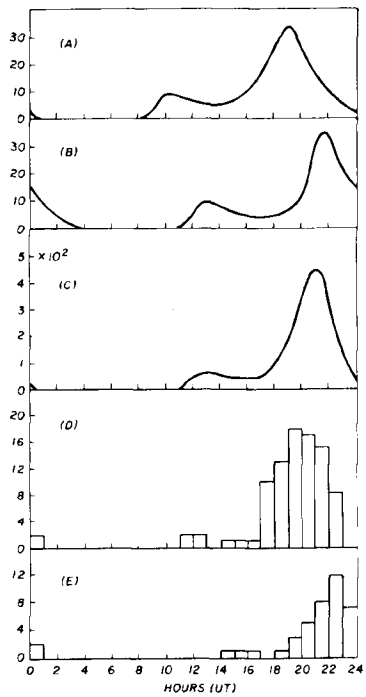


fig. 11. (A),(B) The smoothed hourly distribution of single skip 50-MHz E_s (*fig. 8*) moved to the position of the ionospheric reflections for transatlantic propagation; (C) The *convolution of (A) and (B); (D) the hourly* distribution of transatlantic openings during 1987; (E) the same distribution for 1982-85 (see text for references).

the single-hop beacon was audible for 1592 hours out of a total of 4416 hours, or 36 percent of the time, while the double-hop beacon was audible for 1222 hours, or 28 percent of the time. If the probability of the second reflection was equal to that of the first, the expected fraction of time when it would be audible is $0.36^2 \times 100\% = 13\%$. Obviously the occurrence of E_s at the two points of reflection was highly correlated, implying that the conditions for producing E_s on a certain day act over a considerable area. This has already been suggested from the correlation between European and transatlantic propagation on 50 MHz.

Returning now to the 50-MHz daily pattern — made up largely of contacts in the NNE and SSW directions to Norway and Portugal (as rather few other European countries are able to use this band) — it is assumed that the distribution correctly describes the relative probability of occurrence of 50-MHz E_s at the longitude of the United Kingdom. The following treatment assumes two-hop transatlantic propagation (**fig. 3A**), but the results are almost identical for three hops (**fig. 3B**) apart from lower probability introduced by requiring an extra reflection. **Figure 11A** shows the distribution of **fig. 8** corrected to the region of the first ionospheric reflection at about 20° W, a delay of 1 hour 40 minutes, and **fig. 11B** at the second around 56° W, a delay of 3 hours 45 minutes. The hourly pattern for the occurrence of simultaneous hops should then be the two distributions multiplied together hour by hour; this is shown in **fig. 11C. Figure 11D** shows the *actual* hourly distribution of transatlantic contacts, using the same observers to eliminate (as far as possible) personal bias. The agreement is remarkably good, except for a slight excess of late events. This distribution peaked significantly earlier (2 to 3 hours) compared with transatlantic openings[9] which occurred during 1982-1985 (see **fig. 11E**). It appears that during that period, following the solar maximum, transatlantic events could have originated from a different mechanism (possibly involving F layer propagation).

It can be assumed from the information above that the *short term* probability of E_s at the two locations is uncorrelated and the *daily* occurrence is highly correlated. The fact that the treatment works supports this assumption. This could give a clue to the originating mechanism of E_s.

A similar exercise was performed with the data of the reception of the 50-MHz beacon in French Guiana, FY7THF. This is located in the triple-hop zone of **fig. 3A**, but as the direction is more southerly the reflection points are at about 14° W (+1 hour), 33°W (+2 hours 12 minutes) and 47°W (+3 hours 8 minutes). Because they are close together in time there is a bigger overlap than for the North American path, which must compensate somewhat for the requirement of an additional reflection. Furthermore, **fig. 6** shows that this path traverses a zone of much higher incidence of E_s. The three overlapping curves are shown in **fig. 12A** and their product in **fig. 12B**. The actual distribution[9] of reports of reception in Europe during the months of May, June, and July in the years 1979-1985 is reproduced in **fig. 12C**; again, agreement is very good. The few available reports of reception during 1987 are also consistent.

You should now be able to estimate, with the aid of **fig. 6** and the construction of diagrams like **fig. 12**, the likelihood of a particular path "working", and the best time of day to try. Openings southward employing one or two hops to north and mid-Africa should be fairly frequent considering that they lie in the same time zone, have maximum overlap, and they traverse a zone of frequent E_s. Paths from the United Kingdom eastward towards Asia also look very favorable due to the high incidence of E_s over the European continent (**fig. 6**), although high ground reduces the effective skip distance. For example, the two-hop path to Bahrein reaches grazing incidence over the Black Sea, and a similar time analysis shows a good overlap around 1600 hours UTC (**fig. 13**).

The same treatment was applied to the transatlantic path using the hourly distribution of 144-MHz E_s (**figs. 9A-D**). An overlap is found between about 2030 and 2200 UTC, showing that transatlantic E_s contacts on 144 MHz may well be possible even if very infrequent. So, after a big E_s opening in Europe on 144 MHz, operators in Europe shouldn't just turn off and celebrate, but turn their beams west. If 50 MHz is open, try to set up a transatlantic contact on 2 meters!

comments on the causes of E_s

The wind shear theory has become generally accepted as the explanation for the concentration of ions in a thin layer. The annual regularity and daily unpredictability of E_s remain as inexplicable as ever. On one day intense E_s can occur anywhere from central Europe to the mid-United States, indicating that whatever mechanism concentrates the ionizable material acts over a considerable fraction of the globe. For this reason thunderstorms, essentially local phenomena, can't play a major role as some have suggested. Indeed, the *worldwide* distribution of thunderstorms shows no correlation with the occurence of E_s. Likewise stratospheric "jet streams" producing localized "plaques" of E_s do not seem consistent with the widespread simultaneous occurrence of E_s on a hemispheric scale. The annual pattern of meteor showers is very much like that of the occurrence of E_s in the Northern Hemisphere, peaking with many showers in the May to July period and a smaller peak from December to January. Meteors may originate the metallic material making up the E_s layer, but they can have no immediate influence. The peak E_s season occurs during the summer in the Southern Hemisphere, while maximum global meteor activity happens during the winter. From the success of the path time predictions, it can be seen that the sun clearly plays a decisive (though perhaps not unique) role in ionization. There are indications that the solar wind also plays some part, but this is a subject for another article!

conclusion

The evidence indicates that the origin of the majority of 50-MHz openings listed in **table 1** is multi-hop sporadic E reflections. The rarity of double-hop E_s on higher frequencies (144 MHz) can be explained by the very rapid fall-off of probability as the frequency increases, and also by the lack of suitably equipped and active stations in accessible regions. At the same time, I do not want to discount reports that lack an obvious explanation: apparent one-way propagation, long distance stations which don't appear on great circle beam headings, and the presence or absence of backscatter during these openings.

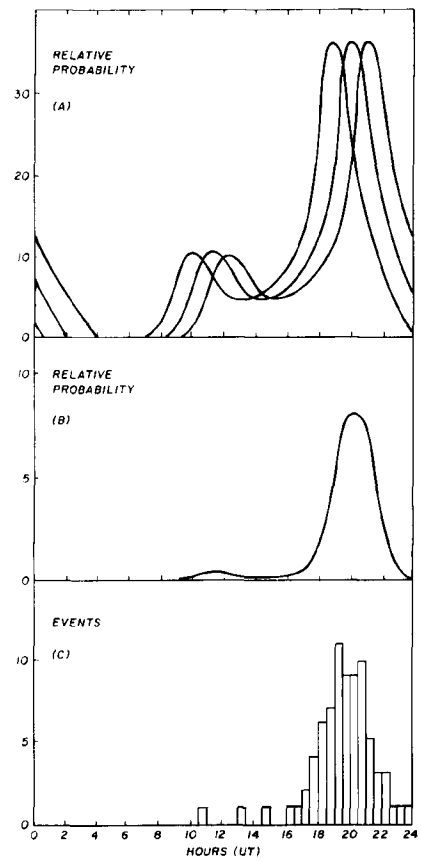


fig. 12. The hourly distribution of the reception of the French Guiana beacon FY7THF in Europe. (A) The probability curves for E_s at the three reflection points; (B) the combined probability curve; (C) the observed distribution[9] for May to July 1979-1985.

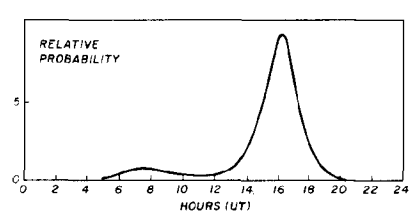


fig. 13. The predicted hourly distribution for liaison with Bahrein.

The localized directional properties of E_s make observations very difficult. Amateur service can be valuable for this kind of study; the 50-MHz band is very suitable for studying and collecting information on E_s

propagation. If a few interested Amateurs calibrate their equipment to give approximate signal field strengths and accurate beam headings, the results could lead to a greater understanding of E_S phenomena.

acknowledgments

I wish to thank Dr. Mike Hapgood and Rita Blake of the World Data Centre for Solar-terrestial Physics, Rutherford Appleton Laboratory, for help with the ionosonde data; Ian White, G3SEK, Steve Cherry, G3SJK, and Jon Eastment, GW4LXO, for discussions; the Rutherford Appleton Laboratory for permission to reproduce the ionosonde data; and Radio Amateurs whose logs extracts have been included.

references

1. N. Wakai, H. Ohyama, and T. Koizumi, *Manual of Ionogram Scaling (Revised Edition)*, July 1986, page 28.
2. E.K. Smith and S. Matsushita (eds.), *Ionospheric Sporadic E*, Pergamon, 1962, pages 257, 323.
3. E.K. Smith and S. Matsushita (eds.), *ibid*, pages 151, 235, et seq.
4. K.L. Miller and L.G. Smith, "Horizontal structure of midlatitude sporadic E layers observed by incoherent scatter radar", *Radio Science 10*, no. 3, March 1975, pages 271-276.
5. K.G. Budden, *The propagation of radio waves*, Cambridge University Press, 1985 §12.7, page 344.
6. E.K. Smith and S. Matsushita (eds.), *ibid*, pages 253-255.
7. "VHF propagation by regular layers, sporadic E, or other anomalous ionization", *Recommendations and reports of the CCIR, 1986*, vol. VI, Rep. 259-6, pages 258-266.
8. "Method for calculating sporadic-E field strength", *Recommendations and reports of the CCIR, 1986*, vol. VI, Rec. 534-2, pages 271-294.
9. G.F. Kimball, G3TCT, "Transatlantic propagation by sporadic E at 50 MHz", *Radio Communication 62* no. 7, July 1986, pages 491-494.
10. K G. Budden, *ibid*, §12.8, pages 345-347.
11. *VHF/UHF Newsletter*, Radio Society of Great Britain, October 1987. Log extracts were provided by G3SEK, GW4LXO, G4VXE, and G8DAZ.
12. J. Morris, GM4ANB, "The New Locator System", *Radio Communication 60* no. 10, October 1984, pages 862-865; also F. Rosvall, *The Radio Amateur's World Atlas*, October 1986.
13. *Radio Communcation 60* no. 4, April 1984, pages 315-316.
14. E.K. Smith and S. Matsushita (eds.), *ibid*, pages 103-107.
15. P. Pasteur, HB9QQ, "VHF UHF Funkverfahren und Betriebstechnik, Aerolit-Verlag Hans G. Auer, Zurich 1982, page 100.
16. The plots were constructed from observations recorded and made available to the author by Prof. M. Harrison, G3USF, at 53° 0'N. 2° 17'W.
17. DLØIGI is located on Predigtstuhl Mountain, South Germany at 47°42'N. 12° 53'E.
18. 5B4CY is located at Zyyi, Cyprus at 34°45'N. 33°19'E.

ham radio

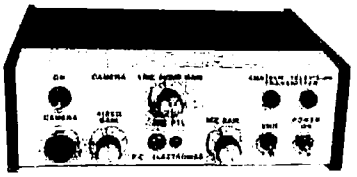
about the author

Geoffrey H. Grayer, BSc, PhD, is an experimental physicist and was engaged in particle physics until 1986. His last experiment was the Nobel Prize winning UA1 at Cern, Geneva, where he was the senior resident physicist working on the experiment trigger. Dr. Grayer was the discoverer of the intermediate vector boson particles W and Z. For the last 18 months he has been involved in satellite experiments investigating lower energy particles found in solar wind. He has been published by the RSGB and works for Rutherford Appleton Laboratory in England. He has been involved in Amateur Radio since 1958.

AMATEUR TELEVISION

NOVICES: NOW YOU CAN TRANSMIT VIDEO WITH OUR NEW TX23-1

Did you know that you as well as all classes of licensed amateurs can easily transmit live action color and sound video just like broadcast TV with our TX23-1 transmitter. Use any home TV camera and/or VCR, computer, etc. by plugging the composite video and audio into the front 10 pin or rear phono jacks. Call or write now for our complete ATV catalog including downconverters, transceivers, linear amps, and antennas for the 70, 33, & 23cm bands.



Only $299

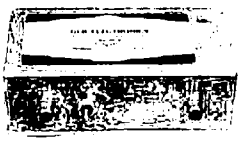
TX23-1 one watt ATV transmitter crystaled for 1289.25 MHz runs on 12-14 Vdc @ .5A. PTL T/R switching. 7x7x2.5". Transmitters sold only to licensed amateurs for legal purposes verified in the latest Callbook or with copy of license sent with order.

(818) 447-4565 m-f 8am-5:30pm pst.
P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006
Tom (W6ORG)
Maryann (WB6YSS)

134

HIGH PERFORMANCE PRESELECTOR-PREAMP

The solution to most interference, intermod, and desense problems in AMATEUR and COMMERCIAL systems.



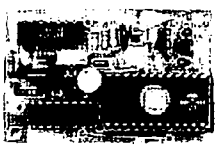
- 40 to 1000 Mhz - tuned to your frequency
- 5 large helical resonators
- Low noise - High overload resistance
- 8 dB gain - ultimate rejection > 80 dB
- 10 to 15 volts DC operation
- Size - 1.6 x 2.6 x 4.75" exc. connectors
- FANTASTIC REJECTION!

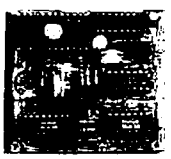
Typical rejection:
±600 Khz@144 Mhz: −28dB
±1.6 Mhz@220 Mhz: −40dB
±5 Mhz@450 Mhz: −50dB

Price - CALL bipolar w/RCA jacks
Connector options: BCN $5, UHF $6, N $10
SUPER HOT! GaAs Fet option $20

AUTOMATIC IDENTIFIERS

ID-1





ID-2

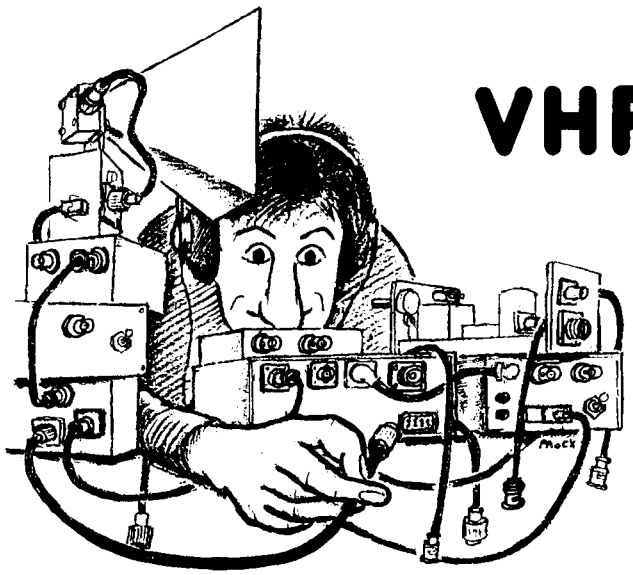
- For transceivers and repeaters - AMATEUR and COMMERCIAL
- Automatic operation - adjustable speed and amplitude
- Small size - easy installation - 7 to 15 volts DC
- 8 selectable, reprogrammable messages - each up to 2 min. long
- Wired, tested, and programmed with your message(s)

Model ID-1 - $54.95 Model ID-2 w/2 to 10 minute timer - $79.95

We offer a complete line of transmitter and receiver strips and synthesizers for amateur and commercial use.
Request our free catalog. *Mastercard and VISA welcome*

GLB ELECTRONICS, INC.
Dept H, 151 Commerce Pkwy., Buffalo, NY 14224
716-675-6740 9 to 4

135



VHF/UHF WORLD

Joe Reisert, W1JR

propagation update-part 3

In June we reviewed the latest VHF/UHF/Microwave DX records.[1] We also discussed the upcoming solar cycle and what effect it may have on some of the ionospheric modes of radio propagation like F2 and FAI. This month we'll discuss some of the other ionospheric modes; then we'll update tropo, EME, and other types of microwave and millimeter-wave propagation.

midlatitude sporadic E

Sporadic E propagation, often referred to as "E skip" by VHFers, is truly the workhorse mode for 6-meter DX. Band openings can occur at any time of the day or year. In North America openings are most common and intense between mid-May and mid-August, with a minor peak ±1 month around the winter solstice (December 22). They occur most often in the late morning or the late afternoon to early evening (local time).

Radio sonde observations show that the ionized cloud responsible for E skip is typically 0.6 to 2.5 miles (1-4 km) thick and is usually located at an altitude of 62 to 75 miles (100-120 km). Therefore, the typical propagation distance varies between about 500 and 1300 miles (800-2100 km), although distances as short as 300 miles (500 km) sometimes occur when there is very intense ionization. Multiple-hop sporadic E openings are most common during the summer, permitting North American stations to work coast to coast as well as CONUS to Hawaii and Europe.

It has long been known that sporadic E propagation was usable through 225 MHz, although openings on 2 meters and above are few and far between.[2,3] While studies have been conducted to see if there is any link between solar activity and sporadic E propagation, no definitive correlation has been proven. In fact, there seems to be a feeling that there may be some inverse relationship, because some of the most intense openings have occurred during years when sunspot activity is low!

There is some possibility that a relationship does exist between sporadic E openings and the position of coronal holes on the surface of the sun. Research conducted by Sid Lieberman, WA2FXB, shows that most North American 6-meter sporadic E openings during June and July occur about 4 or 5 days after the occurrence of an MSB (magnetic sector boundary) crossing.[4]

For many years Amateurs have noticed the presence of lightning storms when sporadic E propagation is present. Sid's research also shows that meteorologists have noted an increase in lightning storms 4 or 5 days after an MSB crossing.

The MSB crossing can be determined from solar data available from WWV propagation reports at 18 minutes after each hour, or from the PRF (Preliminary Report and Forecast of Solar Geophysical Data) available from NOAA (National Oceanic and Atmospheric Administration).* The MSB crossing tends to occur when the "K"

*The PRF is published weekly and is available from NOAA, Space Environment Services Center, 325 Broadway, R/E/SE2, Boulder, Colorado 80303-328. Effective June 30, 1988, there is a $26 per year charge to cover the actual cost of publication.

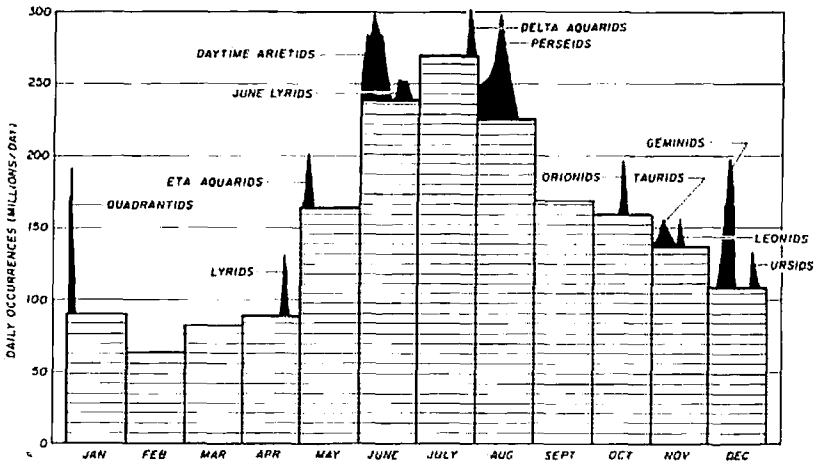


fig. 1. This chart shows the daily occurrence of random meteors. Superimposed on the tops are the major meteor showers at the approximate dates they occur.

index (a measure of magnetic activity) drops to a minimum for at least a few hours.

Dick Bolt, W1DGA, has taken up where Sid left off and studied many years of data on 6 and 2-meter openings. He noticed an increase in sporadic E openings 3 to 5 days after a coronal hole crosses the central meridian, the point on the sun's surface directly opposite the earth. However, he points out that because the surface of the sun is not solid, the rotational period is different between the sun's equator and its poles. Those coronal holes near the sun's equator tend to rotate on about a 25-day basis, while those at 45 degrees latitude take 28 or 29 days per revolution. The typical sporadic E openings will repeat statistically on an approximate 25-29 day basis, depending on the latitude of the coronal hole.

Unfortunately, Dick has not been able to pinpoint the place on the earth where the opening will occur but he's still trying. Stay tuned. This study may bear fruit in the not too distant future.

As has been widely reported in the literature and in references 2 and 3, one probable cause of sporadic E propagation is wind shear — a break in the vertical profile of the horizontal winds. The cause is still under speculation but lightning is definitely suspect. Lightning is most prevalent at the same time of year that sporadic E propagation peaks.

It seems to me that meteors can also have a definite effect on sporadic E propagation. Looking at fig. 1 you'll see that the occurrence of random meteors tends to peak over 250,000,000 per day between June and August, the same time period when sporadic E propagation peaks. The minimum amount of random meteors occurs between mid-January and mid-April when sporadic E propagation is low.

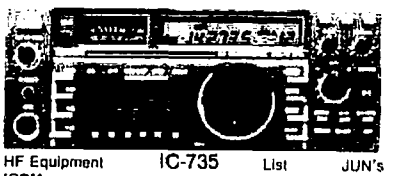
Figure 1 shows that about half of the major yearly meteor showers occur during the same random meteor peak season. Another significant point about this time of year is that several of these same meteor showers occur during the daytime hours when sporadic E propagation is typically most prevalent. Also, the very dense Geminids and Quadrantids as well as the weaker Ursides showers occur near the winter sporadic E peak.

Finally, Swedish scientists have reported that the number of meteors tended to increase during sunspot minimums by up to a factor of 2 during 1963, as compared with the peak of solar cycle 19 in 1956-59.[3] The terminal point of meteors likewise was higher during these same minimum sunspot years.

Throughout the summer of 1987

800-882-1343

ICOM



HF Equipment IC-735	List	JUN's
ICOM		
IC-781 Now Deluxe HF Rig	$5995	Call $
IC-761 Loaded with Extras	2899	Call $
IC-735 Gen. Cvg Xcvr	1099	Call $
IC-751A Gen. Cvg Xcvr	1699	Call $
Receivers		
IC-R7000 25-1300[1] MHz Rcvr	1199	Call $
IC-R71A 100 kHz-30 MHz Rcvr	999	Call $
VHF		
IC-28A/H FM Mobile 25w/45w	469/499	Call $
IC-02AT FM HT	409.95	Call $
IC-u2AT Micro HT	329	Call $
IC-900 Six Band Mobile	639	Call $
UHF		
IC-48A FM Mobile 25w	509	Call $
IC-04AT FM HT	449	Call $
IC-12AT 1.2 GHZ HT	473	Call $
220 MHz		
IC-38A 25w FM Xcvr	489	Call $
IC-37A FM Mobile 25w	499	Call $

KENWOOD

KENWOOD		
HF Equipment		
TS-940S/AT Gen. Cvg Xcvr	2449.95	Call $
TS-440S/AT Gen. Cvg Xcvr	1379.95	Call $
TS-140S Compact Gen. Cvg Xcvr	929.95	Call $
VHF		
TS-711A All Mode Base 25w	1029.95	Call $
TR-751A All Mode Mobile 25w	649.95	Call $
TM-2530A FM Mobile 25w	479.95	Call $
TM-2550A FM Mobile 45w	499.95	Call $
TM-2570A FM Mobile 70w	599.95	Call $
TH-215A 2m HT Has II All	379.95	Call $
TH-25AT 5w Pocket HT NEW	349.95	Call $
TM-721A 2m/70cm FM Mobile	649.95	Call $
UHF		
TH-415A 2.5w 440 HT	399.95	Call $
TH-45AT 5w Pocket HT NEW	369.95	Call $
220 MHz		
TM-3530A FM 220 MHz 25w	499.95	Call $
TH-31BT FM 220 MHz HT	299.95	Call $
TH-315A Full Featured 2.5w HT	399.95	Call $

YAESU

YAESU		
HF Equipment		
FT-767 GX Gen. Cvg Xcvr	1929.95	Call $
FT-757 GX II Gen Cvg Xcvr	1129.95	Call $
FT-747 GX New Economical Performer	889 95	Call $
FL-7000 15m-160m AMP	1995.00	Call $
VHF		
FT-212RH NEW 2m 45w	459.95	Call $
FT-211RH FM Mobile 45w	389.95	Call $
FT-712RH 70cm 35W	499 95	Call $
FT-290R All Mode Portable	599.95	Call $
FT-23 R/TT Mini HT	344.95	Call $
FT-209RH FM Handheld 5w	389.95	Call $
VHF/UHF Full Duplex		
FT-736R, New All Mode 2m/70cm	1749.95	Call $
Dual Bander		
FT-727R 2m/70cm HT	439.95	Call $
FT-109RH New HT	399.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

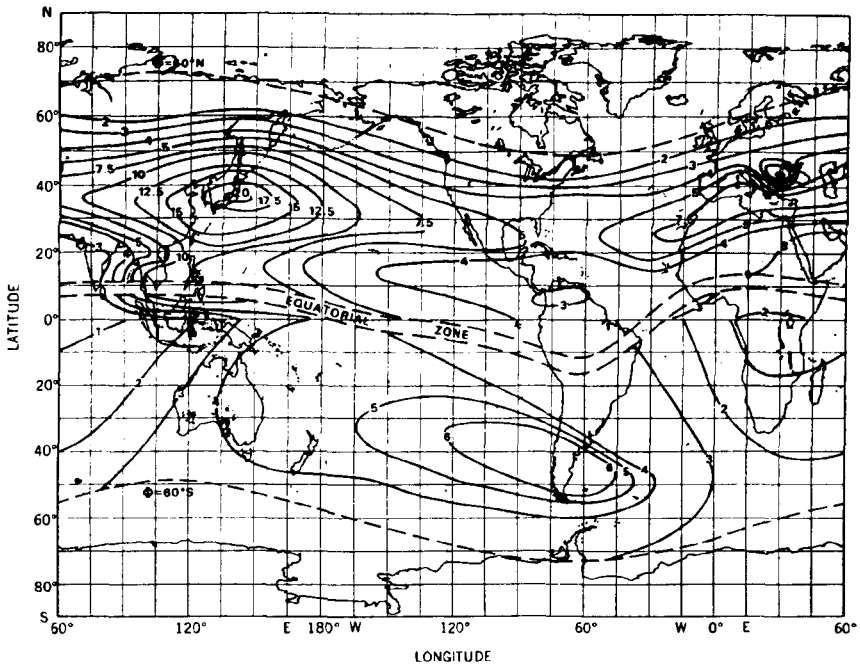


fig. 2. This map shows the percentage of time during the summer months when sporadic E (F_oE_s) exceeds 7 MHz at vertical incidence. This corresponds roughly with the time when 6-meter sporadic E propagation is present.

sporadic E openings were reported almost daily somewhere in North America. Did meteor activity enhance this terrific sporadic E season in 1987 when the solar cycle was near its minimum?

Let's review some of the telltale signs of sporadic E propagation. It is most easily detected at hf by vertical-incidence ionosondes (ionospheric sounding stations). Typical sporadic E critical frequency, or F_oE_s as it is sometimes called, is first detected in the 5-10 MHz region but can go as high as 15-18 MHz when a very intense event is taking place. The higher the frequency of the vertical return, the higher the VHF MUF.

Probably the most interesting data to Amateurs is the F_oE_s summer months worldwide map assembled by Ernest K. Smith, N6HQK, and shown in **fig. 2**. These data are taken from ionosondes when the F_oE_s was about 7 MHz, a typical value to yield 6-meter and higher sporadic E propagation.[5]

Note in **fig. 2** that the highest incidence of summertime sporadic E propagation is in the region around Japan, Indonesia, and near the Mediterranean Sea. South Africa and the northern part of North America have much less. The southern portion of the United States will have about two to three times more openings than the northern states and southern Canada.

We've been discussing 6-meter sporadic E. As mentioned earlier and in reference 2, sporadic E propagation can extend beyond the 135-cm (220 MHz) Amateur band.

Most 2-meter openings occur when the skip distance on 6 meters drops well below 500-600 miles (800-950 km) or when there is noticeable backscatter on 6 meters.[1] The longest worldwide documented two-way sporadic E contact on 144 MHz took place on July 7, 1983 over a distance of 2402 miles (3865 km) between EA8XS (IL28GA) and HGØHO (KNØ7RU). The complementary North American record took place on June 14, 1987 at a distance of 1980 miles (3186 km) between KD4WF (EM92LA) and NW7O/7 (DM25GV).[1,6]

Both contacts were probably double hops where at least two E clouds were linked, presumably with a mid-path reflection from the earth as shown in **fig. 3**. Based on North American geography, coast to coast 2-meter contacts may be possible. However, the proper conditions will most likely favor stations in the southern United States and only take place if two clouds are very close to the optimum geometry (**fig. 3**).

2-meter and higher sporadic E

What does it take for 2-meter or 135-cm sporadic E propagation? This question involves much speculation. Obviously the E cloud must have a tremendous refractive index and be very smooth. Propagation on 6 meters should be "super" and some very short paths might be accessible.

Backscatter on 6 meters would probably also be present, along with evidence of co-channel interference on television channel 7 (174-180 MHz or higher). The conditions on 2 meters should be very good before attempting 135-cm contacts.

These conditions were present when the first 135-cm two-way sporadic E contact took place between K5UGM (EM12MS) and W5HUQ/4 (EM9ØGC) on June 14, 1987 over a

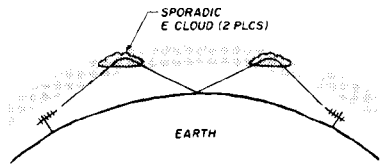


fig. 3. This sketch shows the approximate geometry required for "double hop" sporadic E propagation.

932-mile (1499 km) path.[1,7] Virtually the entire United States was experiencing 6-meter E skip. Some triple hop (and possibly quadruple hop) was noted as stations as far apart as Georgia to Hawaii and Europe to the central United States were making contacts! Numerous stations from coast to coast were making 2-meter contacts, some in both easterly and westerly directions at the same time.

One normally expected sporadic E phenomenon was not present — the shortening of the 2-meter path distance. It had been widely speculated that the 2-meter distance would have to shorten significantly and that different Amateur bands would experience different optimum distances. In fact, the stations completing the first 135-cm contact were in contact on 2 meters at virtually the same time, and no real short distance 2-meter contacts were reported.

Is some rethinking necessary? Perhaps too much emphasis has been placed on the shortened path on the next lower band. If 2 meters is open, give 135 cm a whirl! The higher frequency path requirements are more precise; don't give up.

During the next few years we'll experience the peak of solar cycle 22. Sporadic E openings will probably be somewhat enhanced for the more northern stations as the upper air winds and weather change slightly. Increased interest in solar as well as lightning connections will be studied. The higher the altitude of the lightning strikes, the better the chance for a 2-meter or higher frequency sporadic E propagation opening.[2,3] In North America this tends to happen toward the end of July.

More 6-meter DX will be worked because the number of countries with 50-MHz operating privileges has been greatly expanded, especially in Europe and Africa. There is always a possibility of a 2-meter contact between the United States and Europe, but if it does happen it will probably be between the Azores and a lucky Amateur in the fourth call area (see fig. **2**).

sporadic F propagation?

Sporadic F propagation was recently broached in *Radio Communications*.[8] The discussion came about because some of the United Kingdom to United States openings were too long in duration, and the distances don't always match the typical sporadic E path distances across the continents.

The article references scientific data that verifies the presence of ionized regions up to 93 miles (150 km) above ground level in the normal F layer, and much higher than the typical sporadic E explained earlier in this column. These F layer ionized patches tend to drift slowly downward over a period of several hours until they settle in and dissipate around 65 miles above the earth, the typical height of sporadic E clouds. This is an interesting theory; advanced rockets should make a study possible. Does anyone have any further supporting data?

aurora update

As the solar cycle heats up, so do the number of occurrences of auroral propagation. This mode of propagation should be very common in the next couple of years. While it will virtually wipe out hf propagation, it can yield some great VHF and UHF DX.

Reference 3 illustrates how auroral propagation tends to follow the rise and fall of each solar cycle. However, it's not too common near the solar minimum or at the peak of the solar cycle. To re-emphasize this point, I have updated the information in reference 3 to include the more recent auroras that I have observed here in New England.

Figure 4 clearly shows the trend of auroras just mentioned; the data for 1988 is particularly interesting. Even though only about one-quarter of 1988 is included, the number of aurora observed so far this year is already well ahead of the last two years. It looks as if there will be some very exciting auroral openings in the next year or two.

Although auroral propagation tends to favor stations in the northern latitudes, some of the strongest auroral occurrences have favored stations further south. The reasons for this are simple.

Lower latitude stations have a better reflection angle and can fully use their lower angle of radiation to direct most, if not all, of their signal directly at the aurora. Northern stations often "see" the aurora well above the maximum radiation angle of their antennas.

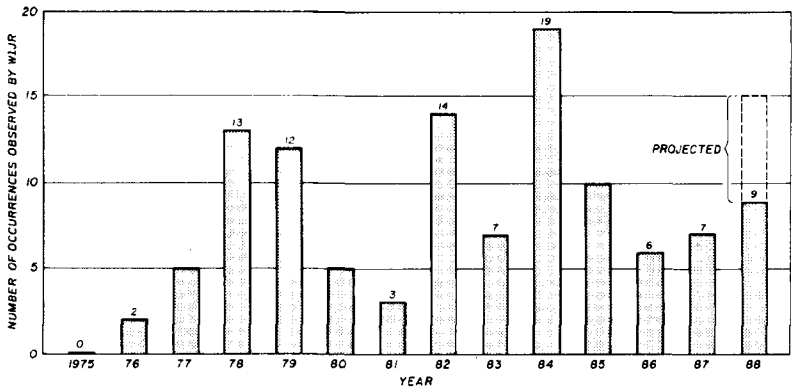


fig. 4. This histogram shows the number of times auroral propagation was observed at W1JR (FN42HN) since 1975. See text for further explanation.

To illustrate this point, stations in the northern United States had the auroral curtain directly over their heads during the now-famous aurora of February 7 and 8, 1986. During that same aurora the North American DX record was extended on both 144 and 432 MHz and equaled on 220 MHz.[1] In all but one case, one or both of the stations involved were below the 40th parallel.

Don't forget that auroras can occur at any time of the day. I've noted several recently that were in progress in the mornings (8-11 A.M. local) but were not productive because there

was "no one around to talk to."

How was I sure that there was aurora present? There was a pronounced flutter noted on hf Amateur signals. I also heard the familiar "buzz" on some of the 6-meter Amateur beacons as well as television video carriers. If you hear these telltale signs, aim your antenna north and put out a call. You may get a surprise.

Most auroral openings occur in the spring and fall, and typically start in the late afternoon or early evening. Remember, the highest usable frequency during an aurora opening tends to occur shortly after the commencement of aurora. If you want to make 135 or 70-cm contacts, move up there quickly after discovering the presence of aurora on the lower VHF bands before the MUF drops too low. Don't give up if the aurora goes away. It often returns in an hour or so.

Knowing when an aurora is expected is not as difficult as predicting sporadic E propagation! Besides the clues noted above, the propagation bulletin on radio station WWV is a great indicator of aurora.

Auroras almost always occur within 30-48 hours after a major solar flare. Listen to WWV at 18 minutes past the hour for word of flares. Expect an aurora imminently whenever the K index announced on the station (it is updated every 3 hours) goes to 4 or higher. The higher the better!

Don't forget that auroras often repeat in 26 to 30 days. This can be ascertained ahead of time by checking the forecasted K index in the NOAA PRF, as mentioned earlier.

Reference 2 notes that aurora propagation is possible beyond 2500 MHz, although Amateurs haven't had any documented success above 450 MHz. However, as you go higher in frequency, the "hot spot" gets very narrow and lots of ERP (effective radiated power) is necessary. These are incompatible requirements since antenna gain will have to be high, making the beam width narrow and increasing the problem of locating the common reflection point.

For these reasons 1296 MHz may be very difficult to conquer on aurora propagation. The signal will be very spread out in frequency and the doppler shift could reach 5 to 10 kHz! For this reason the new 903-MHz band offers some very interesting possibilities. I've tried 903-MHz schedules several times when 432 MHz was usable, but no success to date.

Finally, the doppler shift on aurora propagation is often greater than most Amateurs expect. For instance, I've seen shifts approaching 3-5 kHz at 432 MHz. If you use a transceiver, tune around only with RIT after you call a CQ. Don't forget that a station responding to your CQ doesn't expect you to shift frequency. Also check the range of your RIT. Many of the modern transceivers don't have sufficient tuning range to match the maximum doppler present.

Aurora propagation is a fun mode and a great way to work DX on a band when normal propagation modes won't support extended DX. The present claimed North American DX record on 2 meters is 1347 miles, with 1145 and 1182 miles on 220 and 432 MHz, respectively.[1] A recent claim in Europe would extend the worldwide 2-meter aurora record out to 1439 miles. That's real DX!

auroral E_s

Reference 2 mentioned this interesting form of radio propagation on 6 meters. Basically it resembles sporadic E and takes place a few hours after an auroral opening has faded away.

The problem with catching auroral E openings is that they tend to occur during the very early hours of the morning. They are most often discovered over weekends when someone strolls home from a late evening cocktail party!

Several W1 to W7 auroral E type openings were observed during the descending years of solar cycle 21 (1982-1986). Likewise, openings from Alaska to the lower 48 states and Canada have been reported. With the return of auroras, this could be a good way to increase your DX and VUCC grids.

meteor scatter update

Interest is still high in meteor scatter communications, especially during the major showers like the Perseids and Geminids. Meteor scatter offers 800-1000 mile contacts up through 432 MHz (more on this shortly), and with a little luck out to 1400 miles.

Nowadays 2 and 6-meter meteor scatter contacts are sort of routine. They can be made almost daily using random meteors that typically peak between 5 and 8 A.M. local time. Use fig. 1 to determine the most optimum time of the year. Meteor showers offer more flexibilty on schedule time, better reliability, and greater distances.

European Amateurs have been running meteor scatter schedules since the early 1960s and achieving success daily, even during the daytime on random meteors. What's their secret? They transmit for long periods, typically 1 to 5 minutes, at very high speed CW, usually 100-200 words or 500-1000 letters per minute! This way they only need a very short burst (not much longer than a ping!) to obtain an entire set of calls or reports.

You ask, "Who can copy CW at that speed?" The answer is "no one!" The Europeans' secret to success is to record the output of their receiver at a fast speed, and at the end of the receiving period slow down their tape and replay any recorded bursts at an easy to copy 15-25 words per minute[9].

The European meteor scatter procedure is, in effect, a form of packet communication. Some Amateurs in North America would say this isn't a valid contact, but technology marches on! We now have an abundance of VHF packet communications on 2 and 6 meters. Just tune up to 145.010 MHz some evening and listen to all the strange sounds.

Can this technology be used to VHFer's advantage? The answer is a qualified yes. One problem is that present packeteers are using bandwidths of 15 kHz, 5 to 6 times that of normal 2-meter SSB communications. Using NBFM creates an additional 10 dB disadvantage in the signal strength

required for adequate detection signal to noise ratio.

If you run a packet system with typical antenna gains of 12-14 dBi, at least 500 watts, and the packet protocols presently in use, you incur about a 15-20 dB disadvantage over SSB. But many meteor bursts on 2 and 6 meters, especially during showers, are at least 30-40 dB out of the noise. Therefore, packet meteor scatter even using NBFM is definitely feasible.

The implementation of packet radio for DXing would be a big step forward and probably will be the next technology step. A great enhancement would be to implement one of the hf packet protocols at a lower baud rate (300 baud), using narrow receiver bandwidths that enhance signal to noise ratio. Packet meteor scatter DXing is a wide-open opportunity for DXing VHFers.

Meteor scatter contacts on 135 cm are still rather difficult even with high power and high gain antennas, and are almost entirely confined to the better meteor showers. Contacts on 70 cm, despite some push in the 1970s, are almost nonexistent in North America due to the extremely poor success rate and the apparently poorer results on the Perseids meteor shower of late. Europeans have had several successes on 70-cm meteor scatter lately, but they are all using the CW high-speed system. It looks as if 70-cm operators will have to wait until the Leonids peak in the late 1990s or discover new operating techniques!

Meteor scatter techniques and how to pinpoint shower peaks are discussed in detail in reference 10. Reference 11 stresses the importance of the scheduling time to attain proper meteor shower geometry along with recommended software. Reference 12 discusses the optimum times as well as the peak of the shower. For those interested in optimizing the shower peak, I'd suggest that you obtain a copy of the latest Astronomical Calendar 1988.*

* Astronomical Calendar 1988 is available from Astronomical Workshop, Furman University, Greenville, South Carolina 29613 at $12 plus $3 for postage and handling.

EME update

In the early days of EME communications, contacts were rare and usually involved large groups. Amateurs often used the latest and best equipment available, whether it be homebrew or borrowed from a commercial company. That has all changed. EME operation is now a proven communications technique used daily on 144 and 432 MHz. Two-way contacts have now been made on every Amateur band between 50 and 5760 MHz, as shown on tables 1 and 3 in reference 1.

Six-meter EME is picking up. There are about five stations now active and many more in the advanced building stages. It still requires large antenna arrays and 1,000 watts, but receiver and feedline problems are minimal. Look for an increase in 6-meter EME to fill in the gap until F2 returns.

Most of the worldwide EME activity is concentrated on 2 meters. One station alone has contacted over 800 different stations but it has a gigantic antenna system capable of working anyone with at least 2,000 watts of ERP! Nowadays you can be an appliance operator and still join in on the fun. Everything you need to use is available commercially. [13,14]

EME activity on 135 cm is now very slow, due in part to the small number of stations with the required equipment. It hasn't been helped by recent attacks by commercial companies on the 220-222 MHz frequency spectrum. However, this is still an excellent band and requires an antenna system with much less physical size than 2 meters. So 135-cm EME really deserves more consideration. Typical equipment is described in reference 15.

EME activity on 70 cm is quite prevalent, with several stations having contacted well over 200 different stations. About 45 DXCC countries have been represented, as well as all continents and 50 states. Portable 70-cm EME operation is also popular using 20-foot dishes or arrays of four to eight long Yagis. Typical equipment requirements are described in reference 16.

Our newest UHF band, 33 cm (903 MHz), is just getting started on EME. For a starter antenna a dish with a diameter of at least 12 feet should be sufficient, as long as you run at least 100-150 watts and a feed-mounted low-noise preamplifier. This band looks very exciting for EME in the near future, since only a modest setup is required.

Two-way EME got its start on 23 cm (1296 MHz) in 1960. It does require a more elaborate setup, but many stations with dishes as small as 8-12 feet in diameter are making contacts. Power is a problem and most operators now use two to six 2C39/7289 tubes in a cavity. Circular polarization is standard operating practice, so Faraday is no longer a problem! Many operators use SSB and contacts are now routine. The W2NFA/W2IMU notes are a good guide.*

EME activity on 2304/2320, 3456, and 5760 MHz is much more specialized and beyond the scope of this month's column. Those who are active are using state-of-the-art antennas, and in most cases antenna-mounted preamplifiers as well as power amplifiers. It appears that 10.368 GHz EME will soon be a reality.[1] One of the biggest problems so far is antenna aiming and tracking the moon. Another problem, antenna cost, is being helped by the use of TVRO-type dishes. EME operation is alive and well, so stay tuned.

other propagation modes

A lot of microwave activity is springing up, especially on 3 cm (10.368 GHz) with the commercial availability of solid-state transverters. The difference between a GunnPlexer® running 20 milliwatts and a low-noise transverter operating on CW or SSB with 200 milliwatts (both are typical equipment specifications) is over 36 dB, or an equivalent of 63 times improvement in DX! I'll bet some really serious record attempts will take place shortly on the 13-cm (2304 MHz) through 3-cm bands.

There are many propagation modes and developments and I try to include

*Write Dick Turrin, W2IMU, Box 65, Colts Neck, New Jersey 07722 for further information.

Table 1. This quick reference table lists the most common types of North American VHF/UHF and above propagation. They are in no particular order. Optimum frequencies and a short summary of the typical characteristics are included.

Propagation Mode	Frequencies	Remarks
1. Line of sight	50 MHz and up	Unobstructed path plus some bending extension.
2. F2	50 MHz	Requires high sunspot number, typically above 100 (solar flux >150). Fall is best season.
3. Backscatter	50 MHz	Present during high sunspot activity like F2 or during an intense sporadic E opening.
4. Midlatitude sporadic E	50-225 MHz	Peaks between mid-May and mid-August and again between mid-November and mid-January. Best times are 0900-1200 and 1700-2000 local.
5. TE	50 MHz	Best at equinoxes ±2 weeks. Especially good when sunspot count is high. Optimum time is in late afternoon and early evening.
6. Equatorial FAI	50-450 MHz	Requires high number of sunspots. Should be located ±10 to 15 degrees of the geomagnetic equator. Other characteristics are same as TE.
7. Ionospheric scatter	50-150 MHz	Good from 800-1300 miles at midday in summer. Especially good during years with high sunspot activity. Path loss about 90 dB over free space at 6 meters and 115 dB at 2 meters. Requires high power.
8. Aurora	50-3000 MHz	Often occurs 24-48 hours after a solar disturbance. WWV K ≥4. Aim antenna to northerly direction.
9. Artificial aurora	50-450 MHz	Manmade ionospheric heating. Best when located near one of the heater installations. Very similar to aurora.
10. Auroral E	50 MHz	Similar to sporadic E. Usually occurs a few hours after an aurora has faded out.
11. Meteor scatter	50-450 MHz	Best on 2 and 6 meters for random meteors between 5-8 A.M. local time or at optimum direction and time during meteor showers. Above 225 MHz is very difficult.
12. FAI	50-450 MHz	Usually follows a sporadic E opening. Aim antenna slightly north of direct path. Has characteristics similar to aurora.
13. EME	50 MHz and up	High path loss (250-280 dB typical) depending on frequency. Requires very low noise figure receiver, high transmitter power, and high antenna gain (>20 dB).
14. Tropospheric scatter	50 MHz-20 GHz	Good up to 800 miles between stations having equipment similar to EME.
15. Tropospheric bending and super refraction	144 MHz and up	Best in spring and early fall, especially when there's a slow moving high barometric pressure (>30.0") and when a weather front is approaching somewhere along the path.
16. Tropospheric ducting	50 MHz and up	Similar to tropospheric bending. Best over water and flat land. Antenna elevation is important so you can couple into the duct.
17. Lightning scatter	144 and up	Sporadic. Both stations must aim into storm cell. Characteristics similar to meteor scatter.
18. Aircraft scatter	144 MHz up	Best when a large aircraft is at a high elevation and midway between stations. Usable up to about 500 miles.
19. Knife edge diffraction	1 GHz up	Best over a sharp edge such as a mountain peak especially when it is near one end of the path.
20. Obstacle gain	400 MHz up	Both stations must aim at obstacle such as a large building or mountain. Best when obstacle is near mid-point of path.
21. Rain scatter	5-25 GHz	Aim antenna into storm cell especially if it is elevated. Lots of signal distortion.

the latest record-breaking contacts at the end of each month's column. For those interested in microwave and millimeter-wave propagation, see references 17 and 18 which appeared in "VHF/UHF World" two years ago.

how to find openings

By now you're probably wondering how to discover and use all this super propagation. To take full advantage you must understand the propagation modes available on all bands of interest and know when they are usable. **Table 1** shows most of the major propagation modes, the frequencies where they are most prevalent, and a few words on their characteristics. It provides a quick reference guide.

There are many ways to find openings and just as many ways to miss them. For instance, there will always be a major opening when you least expect it or when you're "out of town!" It is surely a fact that we miss more openings than we catch. But this is rapidly changing with the increased use of calling frequencies (see **table 2**) and greater activity.

There is a problem with the 6-meter calling frequency (50.110 MHz) that has been used for many years. For the last decade it has been recommended as the DX calling frequency, with 50.200 MHz recommended for domestic operation. The latter never caught on. The popular 50.110 MHz is now so totally congested, especially during VHF contests, that DX can't break through the QRM. It has been suggested that all contest and routine activity on 6 meters take place above 50.125 MHz to allow room for the weaker DX near 50.110 MHz.

Another good way to detect openings is to monitor Amateur propagation beacons. They are most prevalent between 50-50.1, 144.05-144.06, and 432.07-432.08 MHz, with some scattered throughout the UHF and microwave bands.

The FCC regulates all automatic beacons (the most common types) on all frequencies below 450 MHz. In recent years, partially because of increased Amateur activity, beacons have sometimes caused interference with EME and other weak signal propagation. As a result, the ARRL VUAC is now soliciting comments on moving all beacons on 2 meters and higher to roughly 75-300 kHz above the present weak signal calling frequencies (rather than below, as is current practice). A note to the ARRL Membership Services Committee with your comments might help. Only after a consensus is found will the FCC be petitioned to approve any freqency changes for automatic beacons on the frequencies below 450 MHz.

The thousands of beacons outside the Amateur bands are rich sources of propagation indicators. Commercial stations like FM, television, and aircraft beacons are a few. Prime beacons to monitor for possible 6-meter openings to Europe are the video carriers of European television at 48.25 and 49.75 MHz.

Other good indicators of possible openings on 6 meters are the Amateur beacons between 28.2-28.3 MHz. Don't overlook above average and out-of-area Amateur activity between 28.3-28.5 MHz, the new Novice phone band.

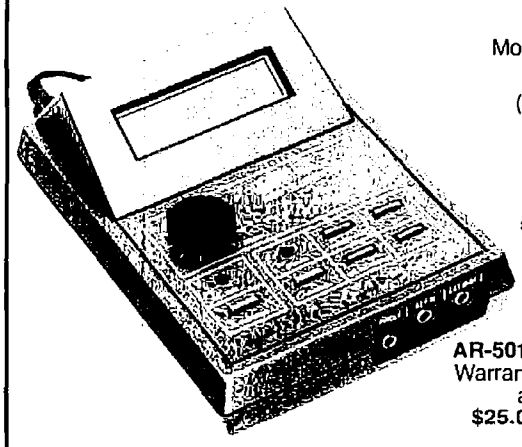
Table 2. This table shows the recommended weak signal calling frequencies on the VHF/UHF bands.

Band	Frequency
6 meters	50.110 MHz DX *
	50.200 MHz Domestic *
2 meters	144.2 MHz
135 cm	220.1 MHz
70 cm	432.1 MHz
33 cm	903.1 MHz
23 cm	1296.1 MHz
13 cm	2304.1 MHz
9 cm	3456.1 MHz
6 cm	5760.1 MHz
3 cm	10.368 GHz

* See text for explanation.

There are also clubs and publications. KA3B now publishes a North American 50-MHz SSB Directory and beacon list and a 6-meter repeater

AR501
BACK TO BASICS...
But far more advanced...



Model AR501 Telegraph Terminal
$229.00
(California res. add $13.74 tax.)

Visa and MasterCard orders are welcomed. Price includes shipping & handling. Purchase orders accepted from Government agencies

AR-501 covered by One Year Limited Warranty. Extended warranty service available at the following rates:
$25.00 – 3 Years $15.00 – 2 Years

AR501 is a compact triple mode CW terminal in a small package (4.5" x 6.25"x 2.25") but a powerful gear to practice and play with. As a CW decoder, it detects morse code between 5 to 30 WPM. **For practice?,** it activates and displays the code. **More?,** it operates as an electronic keyer both standard and iambic. **More yet?,** How about a print-out function? The **AR501** does just that. We offer a stand alone thermal printer as an option.

ACE communications, inc. TOLL FREE 1-800-523-6366
22511 Aspan St., Lake Forest, CA 92630-6321 (714) 581-4900 • Telex 29-7385 • Fax (714) 768-4410

✓ 144

COMPUTERIZE YOUR SHACK

YAESU 747, 757GX, 757GXII, 767, 9600.
KENWOOD TS 440, TS 940,
ICOM R71A, R7000, 735, 751A.
DRIVERS FOR RADIOS ARE MODULAR.
JRC NRD 525.

COMPLETE PROGRAM ENVIRONMENT
MENU DRIVEN AND DESIGNED FOR EASE OF USE.
SCAN FUNCTION ADDED TO RADIOS THAT DO NOT SUPPORT IT.

MENUS FOR THE FOLLOWING:
AMATEUR HF—AMATEUR VHF—AMATEUR UHF
AM BROADCAST—FM BROADCAST—TELEVISION BROADCAST
SHORT WAVE BROADCAST
AVIATION HF(SSB)—AVIATION VHF—AVIATION UHF
HIGH SEAS MARINE—VHF MARINE
MISCELLANEOUS HF, VHF, UHF
MOST POPULAR FREQUENCIES ALREADY STORED
ADDITIONAL LIBRARIES AVAILABLE
COMPLETE LOGGING FACILITY
ALL FREQUENCY FILES MAY BE ADDED TO, EDITED OR DELETED

AVAILABLE FOR IBM PC, XT, AT, 80386 256K RAM
1 SERIAL PORT AND 1 FLOPPY MINIMUM

PROGRAM WITH INITIAL LIBRARIES	**99.95**
RS—232 TO TTL INTERFACE ONLY NEEDED IF DON'T HAVE MANUFACTURERS **INTERFACE ALLOWS 4 RADIOS**	**99.95**
SPECTRUM ANALYZER MODULE	(CALL FOR PRICE)

DATACOM, INT.
8081 W. 21ST. LANE
HIALEAH, FL 33016
AREA CODE (305) 822-6028

✓ 195

CIE Cleveland Institute of Electronics
1776 East 17th St., Cleveland, Ohio 44114

✓ 145

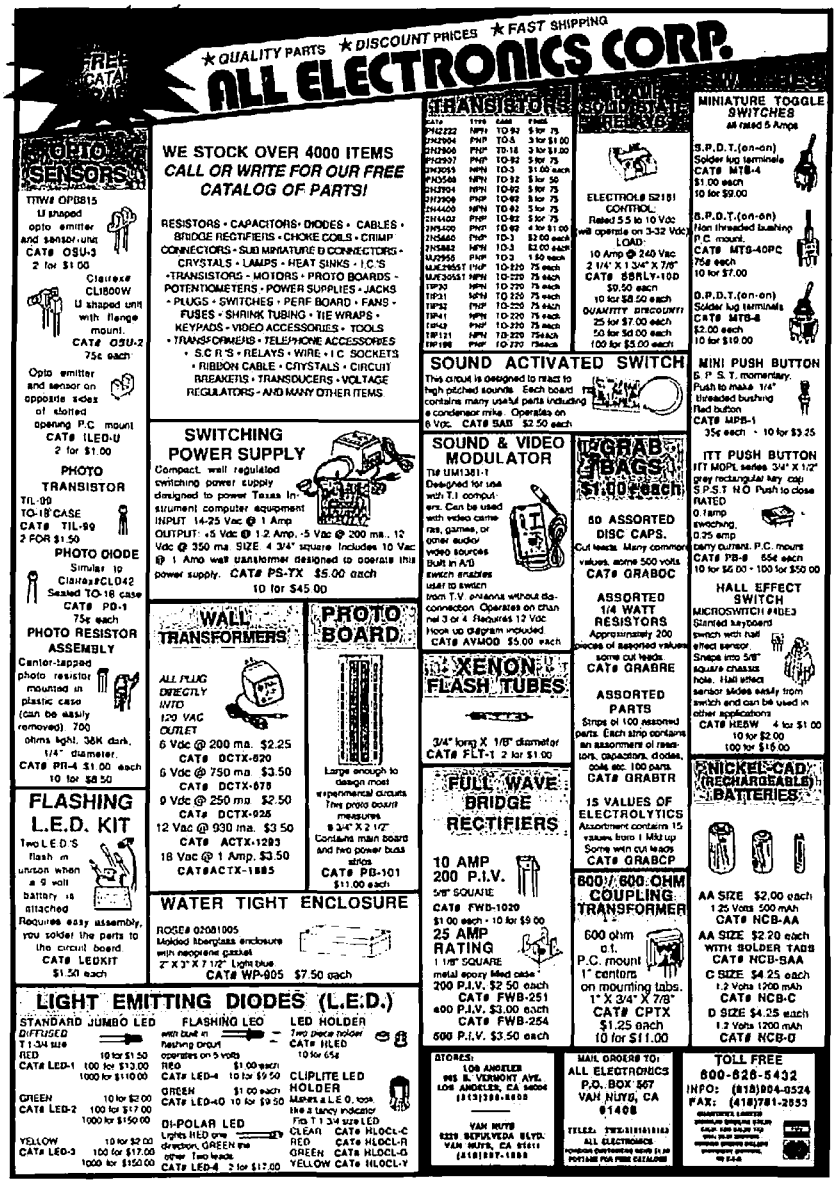
Accredited Member National Home Study Council

CIE is the world's largest independent study electronics school. We offer ten courses covering basic electronics to advanced digital and microprocessor technology. An Associate in Applied Science in Electronics Engineering Technology is also offered.

Study at home — no classes. Programs accredited and eligible for VA benefits.

CIE Cleveland Institute of Electronics
1776 East 17th St., Cleveland, Ohio 44114
YES! I want to get started. Send me my CIE school catalog including details about the Associate Degree program.

Print Name _____
Address _____ Apt _____
City _____ State _____ Zip _____
Age _____ Area Code/Phone No. _____
Check box for G.I. Bulletin on Educational Benefits
☐ Veteran ☐ Active Duty MAIL TODAY!
AHR-03



147



148

directory.* Other VHF publications are of interest and many are listed in reference 19. (I hope to publish a club list soon.)

There are net frequencies and special VHF activity frequencies on the hf bands that often help spot VHF openings. An example is 3818 kHz, the frequency of the Central States VHF Society net which is often used as an evening gathering place for VHFers, especially during meteor showers. EMEers meet on Saturdays and Sundays from 1600 to approximately 1900 UTC on 14.345 MHz. The 6-meter activity frequency is 28.885 MHz, which is often busy when 6-meter openings or crossband activity is expected.

How about a dedicated packet net for exchanging VHF/UHF information, activity, band openings, and beacon frequencies? Dxers in W1/W2/W6 (and perhaps other places) have such nets and bulletin boards near 144.95 MHz. These nets broadcast rare DX activity as well as WWV solar activity. They also allow interconnects between linked stations over a wide coverage area. This could be an invaluable source of information exchange for VHF and above enthusiasts. Imagine seeing a flash that ZD8MB is being heard in the states on 50.110 MHz or KH6HME is being heard in California on 1296 MHz! Why not give it a thought. Maybe the DXers would let us jump on their net until we can establish our own systems.

summary

I hope this month's column has brought you up to date on all the latest propagation happenings on the frequencies above 50 MHz. Reviewing the references listed should help you understand the propagation opportunities available on these bands. Table 1 can be your mini propagation guide. Good luck on your search for new DX.

notes

Per Amateur Satellite Report (AMSAT newsletter), bulletin no. 171, March 21, 1988: Dr. Patrick Macintosh, the Director of Solar Physics

*Harry Schools, KA3B, 1806 S. Newkirk Street, Philadelphia, Pennsylvania 19145, $8 for each directory.

Research at NOAA's Space Environment Laboratory, Boulder, Colorado, reports that the peak of solar cycle 22 may be a lot higher and earlier than originally predicted. Let's hope he's right. Check WWV and the PRF.

Just a reminder. The latest accepted ARRL VUAC Band Plan as shown in the ARRL Repeater Directory lists the 33-cm calling frequency as 903.1 MHz with EME activity between 903.0 and 903.05 MHz. Using these frequencies will help reduce QRM from other services and bring interested parties together so they won't miss openings by being spread out in frequency.

new records

On March 22, 1988 at 1300 UTC Gene Monk, W4ODW, Niceville, Florida (EM60SM) worked Al Ward, WB5LUA, McKinney, Texas (EM13QC) for a new extension of the 33-cm (902-928 MHz) tropo DX record. Gene was running only 10 watts on 903.1 MHz SSB while Al was running 150 watts to a single 47-element loop Yagi. Tropo was reported between the Florida Panhandle and Texas for a few days and signals were quite strong. The distance was 623 miles (1003 km). **Table 1** from last month's column is already obsolete! Congratulations to Gene and Al.

acknowledgments

I would particularly like to thank Dr. Ernest K. Smith for sending me the copy of his F_0E_s maps article.[5] Thanks also to those who took the time to write with comments and suggestions for future columns.

important VHF/UHF events

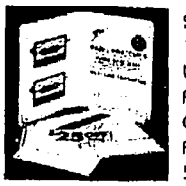
July 1	*± 1 month. Look for USA to Europe openings on 6 meters*
July 2	*EME perigee*
July 13	*New moon*
July 16-17	*CQ VHF WPX Contest*
July 20	*± 3 weeks. Look for 2-meter sporadic E openings*
July 21-24	*Central States VHF Conference, Lincoln, Nebraska (contact WDØDGF)*
July 28	*Predicted peak of the Delta Aquarids meteor shower at 2100 UTC*
July 30	*EME perigee*
Aug 6-7	*ARRL UHF Contest*
August 11	*Predicted peak of the Perseids meteor shower at 1900 UTC*
August 12	*New moon*
August 20-21	*ARRL 10 GHz Cumulative Contest, first weekend*
August 25-28	*Microwave Update 1988 Conference Estes Park, Colorado (contact WØPW)*
August 27	*EME perigee*

references

1. Joe Reisert, W1JR, "VHF/UHF World: Propagation Update-part 2," *ham radio*, June 1988, page 38.
2. Joe Reisert, W1JR, "VHF/UHF World: The VHF/UHF Primer: An Introduction to Propagation," *ham radio*, July 1984, page 14.
3. Joe Reisert, W1JR, "VHF/UHF World-Propagation Update," *ham radio*, July 1985, page 86.
4. S.J. Lieberman, WA2FXB, "Chasing the Elusive E Skip on 2 Meters," Copyright 1985. Copies available from WA2FXB.
5. Ernest K. Smith, "Temperate Zone Sporadic-E Maps IF_0E_s>7 MHz)," *Radio Science* Vol. 13, number 3, pages 571-575, May-June 1978.
6. Joe Reisert, W1JR, "VHF/UHF World: Low-Noise Receiver Update-part 1," *ham radio*, November 1987, page 77.
7. Joe Reisert, W1JR, "VHF/UHF World: Impedance-Matching Techniques," *ham radio*, October 1987, page 27.
8. Pat Hawker, G3VA, "Technical Topics," *Radio Communications*, RSGB, October 1987, page 749.
9. Ken Willis, G8VR, "Meteor Scatter-European Style," *QST*, November, 1986, page 35.
10. Joe Reisert, W1JR, "VHF/UHF World: Improving Meteor Scatter Communications," *ham radio*, June 1984, page 82.
11. Joe Reisert, W1JR, "VHF/UHF World: Meteor Scatter Communications," *ham radio*, June 1986, page 68.
12. Joe Reisert, W1JR, "VHF/UHF World: Loose Ends," *ham radio*, February 1988, page 82.
13. Joe Reisert, W1JR, "VHF/UHF World: Minimum Requirements for 2-Meter EME-part 1," *ham radio*, August 1987, page 39.
14. Joe Reisert, W1JR, "VHF/UHF World: Minimum Requirements for 2-Meter EME-part 2," *ham radio*, September 1987, page 65.
15. Joe Reisert, W1JR, "VHF/UHF World: 220 MHz EME Requirements," *ham radio*, September 1984, page 45.
16. Joe Reisert, W1JR, "Requirements and Recommendations for 70-cm EME," *ham radio*, June 1982, page 12.
17. Joe Reisert, W1JR, "VHF/UHF World: Microwave and Millimeter-wave Propagation-part 1," *ham radio*, July 1986, page 82.
18. Joe Reisert, W1JR, "VHF/UHF World: Microwave and Millimeter-wave Propagation-part 2," *ham radio*, August 1986, page 69.
19. Joe Reisert, W1JR, "VHF/UHF World: Keeping VHF/UHFers up-to-date," *ham radio*, March 1985, page 126.

GORDON WEST'S
RADIO SCHOOL

21 DAY NOVICE



2 code tapes
112 page book
World maps
Frequency charts
Course certificate
Free magazine coupon
50 piece literature set!

$70 in equipment certificates from ICOM, KENWOOD, and YAESU $19.95

COMPLETE NOVICE COURSE $49.95
4 code tapes, 2 theory tapes, 2 text books, code oscillator set, examiner test packet, and $70 discount coupons.

NOVICE TEXTBOOK $4.95
Written by Gordon West, this 112 page book contains all Novice questions and answers

NOVICE CODE COURSE $39.95
6 tape stereo code course for learning the code from scratch. Includes certificates

TECHNICIAN THEORY COURSE $19.95
2 theory tapes & 2 textbooks.

GENERAL THEORY COURSE $19.95
2 theory tapes & 2 textbooks.

TECHNICIAN/GENERAL COURSE $19.95
Combined tech & general course with 4 tapes and 1 book.

THE COMPLETE GENERAL $49.95
4 tapes & 2 books for theory plus 6 tape stereo code set for CW speed building.

GENERAL CODE COURSE $39.95
6 tape stereo code course for CW speed building from 5 wpm to 13 wpm.

THE COMPLETE ADVANCED $49.95
4 tapes & 2 books for theory plus 6 tape stereo general or extra class code course (Specify which CW tapes you want.)

ADVANCED THEORY CLASS $19.95
4 tape stereo theory course plus fully illustrated theory book

THE COMPLETE EXTRA $49.95
4 tapes & 2 books for theory plus 6 tape stereo code set for CW speed building 13 wpm to 22 wpm+!

EXTRA CODE COURSE $39.95
6 tape stereo code course for CW speed building from 13 wpm to 22 wpm+.

EXTRA THEORY CLASS $19.95
4 tape stereo theory plus fully illustrated theory book.

GORDON WEST ELECTRONICS BOOK
200 page marine electronics book plus marine mobile antenna hints $19.95

COMMERCIAL TEST PREP BOOK $29.95
BRASS CODE KEY & OSCILLATOR $19.95
PLASTIC CODE KEY & OSOLLATOR $14.95
COPPER GROUND FOIL 60¢ FOOT

SINGLE CODE TAPES
$9.95 EACH • BUY 2, GET 3rd ONE FREE
• 5 wpm Novice Tests • 5 wpm Random Code
• 5-7 Speed Build • 7-10 Speed Build • 10 Hump Jump
• 10-12 Speed Build • 12-15 Calls & Numbers
• 13 Random • 13 Test Prep • 5-15 General Quiz
• 13 Car Code • 13-15 Speed Build • 15-17 Speed Build
• 17-19 Speed Build • 20 Random • 20 Test Prep
• 20 Car Code • 10-24 Extra Quiz

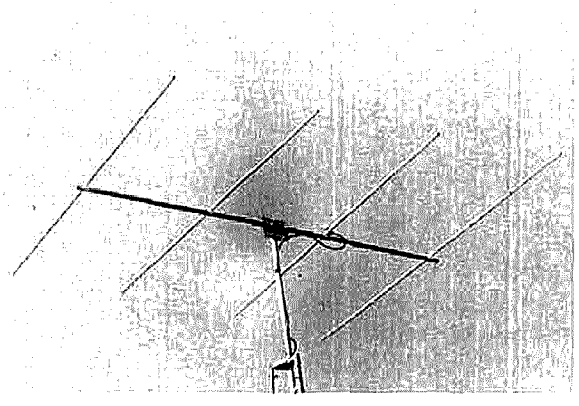
Pass any upgrade & receive $25 Kenwood rebate
• • plus a license holder & wall certificate FREE! • •

Slow code uses 13 wpm character speed. Same day service. Add $3.00 UPS for courses, or $1.00 for single tapes. 100% return policy

GORDON WEST RADIO SCHOOL
2414 COLLEGE DR., COSTA MESA, CA 92626
Mon.-Fri. 10-4pm (714) 549-5000

146

cheap and dirty 6-meter beam



Inexpensive way to attach elements

For over 40 years the Amateur Radio fraternity has used an antenna construction technique known as "plumber's delight". This method, based on the fact that the center of a half-wave antenna lies at a 0-voltage point, allows the center of the element to be grounded to the boom material and can make for easier rotary beam construction.

Many different ways of attaching elements to the boom have been tried over the years. Some have been as simple as a single "U" bolt with holes drilled in the element; others have been much more complicated. The beam construction method described here is simple and inexpensive. It cost me less than a dollar!

Several years ago, the local Amateur Radio club needed a 6-meter beam for Field Day operation. Not wishing to expend much in the way of funds, we made a quick search of the antenna graveyard. We found various pieces of aluminum but no way to attach the elements. Then it hit me; just use simple E.M.T. clamps (**photo A**)!

These clamps, often made of galvanized iron, are available from any well-stocked hardware store for as little as 7 cents apiece. Drill the element material to pass a No. 10 bolt and the clamp easily attaches to the element. Next, drill two 1/8-inch holes into the boom, through the clamp, to pass a No. 8 sheet metal screw. Viola! A "cheap and dirty" way to attach the elements to the boom.

This antenna worked great for Field Day, but was relegated to the antenna graveyard soon after. Over the next several years, the boom and other pieces found their way into other antenna projects and soon only the elements remained. I finally decided to resurrect the antenna, and the "Cheap and Dirty 6-meter Beam" was the result.

The beam consists of four elements on a 10-foot boom (antenna dimensions shown in **fig. 1**). The material used for the boom is two sections of Radio Shack heavy-duty mast that telescopes approximately 6 inches. The elements are made from 5/8-inch 6061-T3 aluminum, and the gamma match from 3/16-inch rod. You could probably use Radio Shack light-duty mast for the boom material, but the difference in cost is minor.

To build the antenna, cut the elements to length, drill them to attach to the E.M.T. clamps, and attach them to the boom. To attach the boom to the mast, drill a sheet of aluminum about 12 x 6 inches to accept "U" bolts. The model built at W5UOJ (see lead photo) uses Radio Shack TV-type "U" bolts for both the boom and mast. However, the actual "U" bolts used depend on the size of the mast and boom material.

The gamma match, shown in **fig. 2**, is straightforward; it's a piece of 3/16-inch rod approximately 14 inches long. Make a movable strap from a small piece of aluminum and attach it near the end of the material. A second strap attaches the rod to the variable capacitor. A small plastic enclosure can be used for weatherproofing; I didn't use one.

Instead of a plastic enclosure, the variable capacitor was set, then wrapped with a plastic bag and black plastic tape. This appears to work; the capacitor has

Glen E. Zook, W5UOJ, 410 Lawndale Drive, Richardson, Texas 75080

made it through two separate ice storms so far. But, if in doubt, use a small plastic box.

You don't need stand-off insulators in the gamma match assembly — the gamma rod isn't long enough to need any and the aluminum strap gives enough support. By the way, the gamma capacitor used at W5UOJ was an old "APC" type, but you can use any variable with an appropriate value.

There are two methods of adjusting the gamma match for best SWR. The first is to mount the antenna directly on a tower, mast, or other suitable point and make the necessary adjustments. A simpler method is to take a wooden stepladder, prop the antenna on it pointing upward, and make your adjustments to the gamma match.

You don't have to use 6061-T3 for the elements; almost any aluminum tubing from 1/2 to 5/8 inch will work. The lengths are such that any droop is insignificant. The gamma rod can be made from aluminum ground wire, like the kind available from Radio Shack, but probably will have to be a couple of inches longer for the best match.

You'll probably have to use bolts about 1/2 to 1 inch longer than necessary when attaching the E.M.T. clamps to the elements because the clamps are a bit too short. But the bending that results from tightening the bolts firmly secures the elements to the boom.

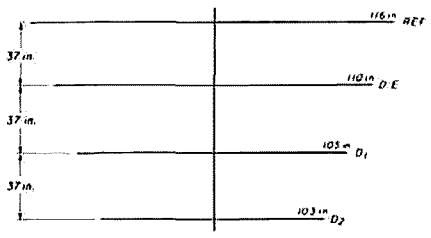


fig. 1. Antenna dimensions.

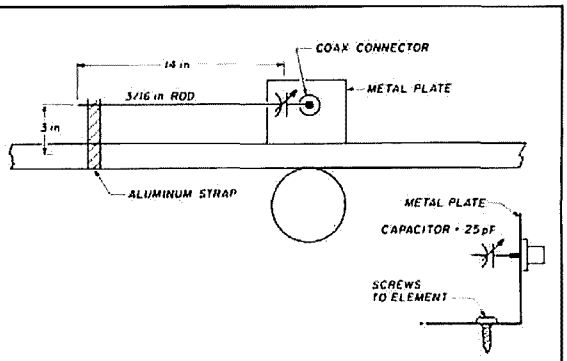


fig. 2. Gamma match.

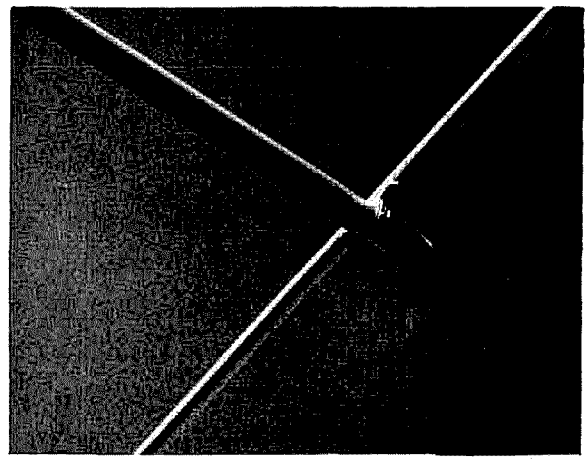


photo A. An E.M.T. clamp makes an excellent method of connecting the elements to the boom.

The extra bolt length can be cut off with a pair of side-cutters. Next, drill the clamp on each side and secure it to the boom with sheet metal screws.

The clamps used with the 1-1/4 inch boom material are for 1-inch E.M.T. For a 1-1/2 inch boom, use clamps for 1-1/4 inch E.M.T. Antennas built for higher frequency operation can use smaller clamps. Boom material 1-1/2 inches in diameter results in a stronger beam.

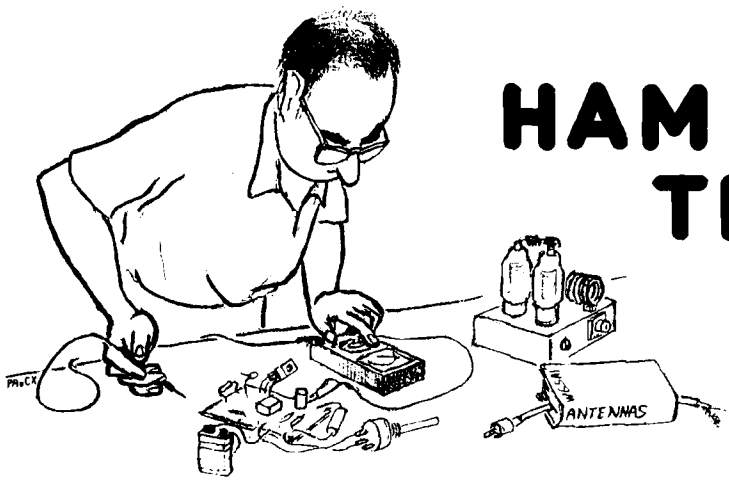
If you use Radio Shack boom material, make sure that the two boom halves do not turn. Put the two sections together and drill a 1/8-inch hole. Then, secure the boom material with a No. 8 sheet metal screw.

The same technique was also applied to a three-element 10-meter beam used for OSCAR 6 and 7 work. Here, however, I used boom material 1-1/2 inches in diameter along with the heavier clamps to secure the elements to the boom.

Obviously, there are other ways to secure elements to the boom in a "plumber's delight" Yagi. But I doubt you'll find any as inexpensive. Although I haven't tried it, there's no reason why E.M.T. clamps can't be used for 6-meter antennas with more than four elements, or smaller clamps for 2 meters and up.

While the actual performance of this antenna has not been checked on an antenna range, it compares favorably with commerically made four- and five-element beams used in this area. The total cost was less than $15; the aluminum and the variable capacitor were surplus. You'll spend approximately $25 to $30 on this antenna if you buy all the parts. But, it's still cheaper than buying a beam and takes only a few hours to build.

ham radio



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

line voltage and power tube life

Have you checked the cost of a replacement power tube recently? Just like the cost of automobiles, houses, and other items, it has gone up over the years. Taking good care of the tubes in your linear amplifier will put money in your pocket in the long run.

Control of filament voltage is a main factor in determining vacuum tube life. Most power tubes specify filament voltage excursion limits — in most cases, ±5 percent of a nominal value. The popular 3-500Z high-μ power triodes have a nominal filament voltage of 5.0 with limits of 4.75 and 5.25 volts.

Undervolting the filament will seriously limit the electron emission and the maximum plate current level; overvolting the filament will reduce the emission life of the tube. The voltage limits specified by the tube manufacturer strike an economical compromise between emission and filament life.

During World War II the 6C21 pulse tube was developed. It was a 450TH triode whose 7.5-volt filament was uprated to 8.2 volts. The tube had very high pulse emission for its size, but the guaranteed tube life was derated to 200 hours.

measuring filament voltage

Measure filament voltage at the tube socket so that the resistance of filament wiring or chokes does not degrade the reading's accuracy. Use a digital voltmeter or an iron-vane, d'Arsonval type rms-responding analog instrument. The latter can be identified by the nonlinear ac scale which is highly compressed at the low-voltage end. The old Weston model 476, 3-1/2 inch meter with a 0 to 8-volt scale is ideal for 5-volt tubes. It can often be found for a few dollars at a flea market. You can have the calibration checked at the electrical laboratory at a local college, or at a meter repair shop.

The popular digital voltmeter used for ac measurements is a peak-reading device, calibrated for an rms reading. It's acceptable, but accuracy is not as good as the iron-vane analog meter in cases where the power line harmonics are particularly high. In any case, both instrument types are satisfactory for general Amateur use.

The common volt-ohmmeter is not recommended for accurate filament voltage measurement. It has a dc meter movement with a series rectifier added for ac measurement. Calibration can change quickly if the rectifier is accidentally overloaded or slowly as the rectifier ages. In addition, any substantial harmonic content of the power line casts doubt on the indicated reading, even if the meter is accurately calibrated for 60 Hz use.

meter accuracy

The accuracy of many small meters is ±2 percent of the full scale reading. This doesn't leave much margin for error when you're trying to ascertain voltage limits of ±5 percent. The solution is to have the meter calibrated as described earlier. My filament voltmeter was accurately calibrated at the 5-volt scale marking. I take good care of the meter and keep it in a safe place, away from bumps and jars.

line voltage limitations

As the filament voltage limitations of the 3-500Z are ±5 percent, the primary line voltage must be held within these

limits. In the thirties the nominal line voltage in the United States and Canada was 110 volts; in the forties it was raised to 115, and then to 117 just after World War II. By the late fifties the nominal line voltage was about 120 volts. Now, it may run as high as 125 volts in certain parts of the country.

Line voltage limits are set by the Public Utility Commission in each state. In California, the voltage limits are 115 and 125 volts, centered about 120 volts. This amounts to a plus or minus tolerance of about 4.5 percent, which is within the 5-percent voltage tolerance established for the 3-500Z. So, if the manufacturer of the amplifier using the 3-500Z designs his transformer to deliver the required filament voltage and current at a primary voltage of 120 volts, the filament voltage will remain within limits even if the line voltage varies within the proscribed excursions.

Most imported linear amplifiers are manufactured with a power transformer designed for the line voltage of the country where the amplifier will be used. Unfortunately, many of the amplifiers are designed around a 115-volt primary requirement, because this is a common line voltage in many countries. When such an amplifier is run on a nominal 120-volt line, the filament voltage often exceeds the upper limit specified by the manufacturer.

I have a popular imported amplifier using a pair of 3-500Z tubes. The instruction manual specifies a power source of either 120 or 240 volts. However, when checked with accurate meters, it was found that a line voltage of 120 resulted in a filament voltage of 5.22 volts at the tube socket — dangerously close to the upper limit of filament voltage excursion. Using a variable voltage transformer, I determined that a primary voltage of 115 provided the correct filament voltage. I then checked the results under the 240-volt condition and found that a line voltage of 230 provided the correct filament voltage.

Obviously, the power transformer of the amplifier had been designed for a 115/230-volt primary source. When run on a 120/240-volt source, the amplifier requires an auxiliary primary circuit step-down transformer to achieve the correct nominal filament voltage (**fig. 1**).

the correction transformer

Because I wanted to run the amplifier from the nominal 240-volt circuit, I had to reduce the primary voltage by 10 volts. Checking line voltage over a

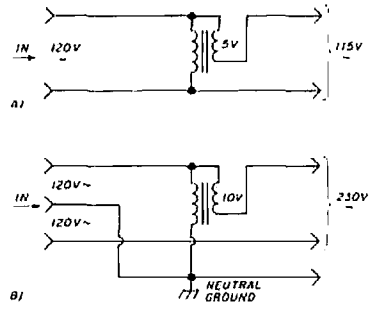


fig. 1. (A) 5-volt transformer "bucks" line voltage. Depending upon polarity of secondary, the transformer either boosts or reduces line voltage. (B) 115/120 volt transformer can be used as 240-volt circuit with primary connected between one side of line and neutral. Notes: Neutral ground is attached to chassis ground in most amateur equipment. Transformer secondary must carry full primary current of amplifier.

period of days showed that the average value ran close to 244 volts. This meant that a 14 volt, rather than a 10 volt, step-down transformer was required. According to the operating manual, the maximum primary current of the amplifier was about 14 amperes, so the transformer has to deliver 14 volts at about 14 amperes. An oddball!

Looking for a transformer like this in a catalog may be a waste of time. Even if you find one, it will be very expensive. A suitable transformer can often be purchased at a flea market. If the current capacity is OK, you may be able to run it from a variable-voltage transformer (like a Variac™ or Powerstat™) in order to hit the required voltage "on the nose" (**fig. 2**). The transformer can have either a 120 or 240-volt primary. Various hookups are shown in the illustration.

GILFER SHORTWAVE

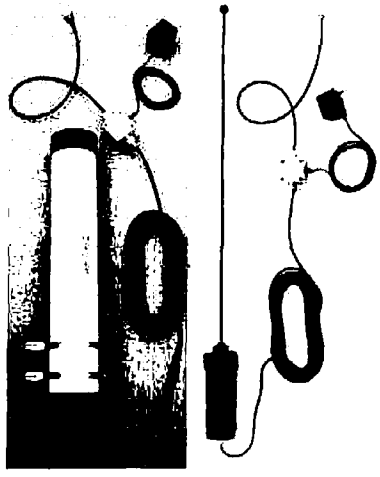
"First in Shortwave, first in service to the world's SWLers"



Datong Multi-Mode Filter

It separates the signals you want from those you don't – with multi functions. Fully automatic notch filter removes heterodynes and other steady tone interference. Independent low and high pass filters stop "monkey chatter" and other off-tune interference, tuning 200-3500 Hz. Second notch filter manually tunes 200-3500 Hz. For speech, all filters work independently for flexibility. A special mode for CW and RTTY combines the filters into a 12-pole filter with super skirt selectivity and non-interacting controls. Works with any receiver, easy to install. Features 29 ICs with latest switched capacitor filter technology.

FL-3 ..... $229.95 (+$4)

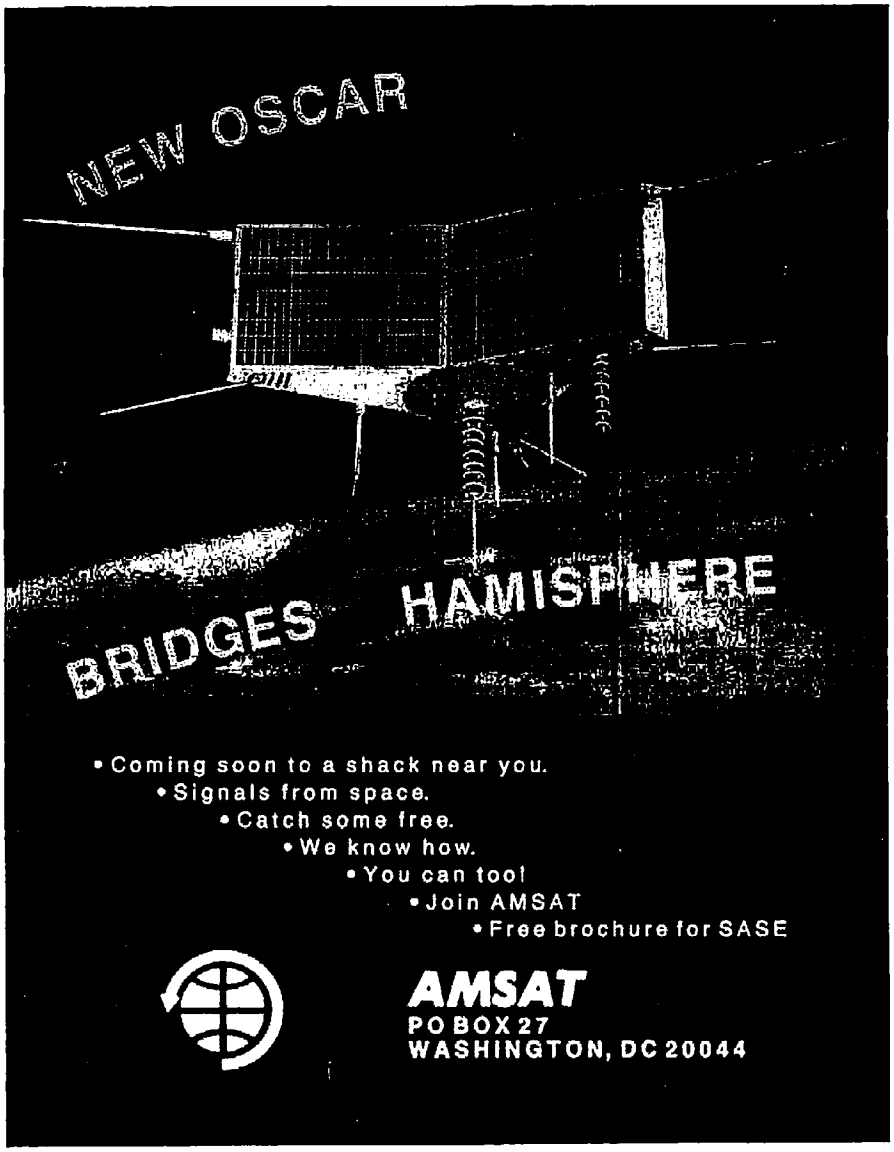


Dressler Active Antennas

Model ara 30 ..... $159.95 (+$8)
For HF use up to 30 MHz and more. Features low noise field effect transistor acting as an impedance transformer together with a high linear CATV transistor. A push-pull amplifier with noiseless negative feedback produces high linearity for low noise. Installs vertically, outdoors or in. Includes 26' cable, interface, and AC adaptor.

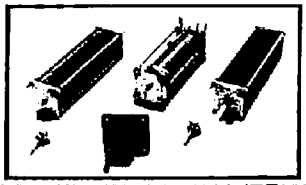
Model ara 900 ..... $189.95 (+$8)
For VHF-UHF and Scanners. Range 50-900MHz and more. Has low noise high gain 2-stage amp. With 1 gHz bandwidth. Gain is 15-16dB. Mounts indoors or out. Includes 26' cable, interface, and AC adaptor.

ORDER PHONE: 1-800-GILFER-1
Prices subject to change w/o notice
GILFER SHORTWAVE
52 PARK AVE. PARK RIDGE, NJ 07656
Ph 201/391-7887



✓ 156

1500 + WATT TRANSMATCH KIT $169.95



BASIC KIT: INDIVIDUAL ITEMS

1 - rotary inductor 28μh..... $59.00
2 - 6:1 ball drives.....$9.00 ea.
1 - 0-100 turns counter.....$65.75
2 - variable capacitors
25-245 pf 4500 v.....$44.00 ea.

OPTIONS—

enclosure (pictured in Sept. 88 CQ). $64.00
4:1 balun kit.....$22.50
dials, terminals, chassis, ceramic standoffs, hardware, toroids, amp components, B&W call stock, etc.

OTHER KITS

Article Reprints (refundable).....$1.50
G3RUH, PSK Packet Modem, Satl./Terrestrial $99.00
PC Board for above only, delivered.....$27.99
Ten-Tec Designer Cabinet for above.....$12.00
K9CW Memory Contest Keyer.....$109.00
Yaesu FRG-9600, .1 to 60 MHz Converter....$94.95
20m CW, 15w Transceiver (H.R. 6/87).....$159.95
50W 75M SSB XCVR.....$199.95

Factory Wired

Nel-Tech DVK-100A (New Model).....$269.00
B & W PT-2500A Amp.....$1,670.00
B & W VS1500A Tuner.....$366.00
Amp Supply/Ameritron Linears.....CALL

Shipping Extra Unless Noted

Catalog $1.00

RADIOKIT • P.O. Box 973-H
Pelham, NH 03076 • (603) 635-2235

✓ 157

keeping track of filament voltage

In most cases it is not practical to attach a permanent filament voltmeter to the amplifier. An iron-vane meter connected across the primary circuit is helpful. I have one mounted in a small box that sits next to the SWR meter on my operating table. It didn't cost much and doesn't take up much space. But I feel very comfortable with it, especially when I contemplate the cost of replacement tubes for my amplifier!

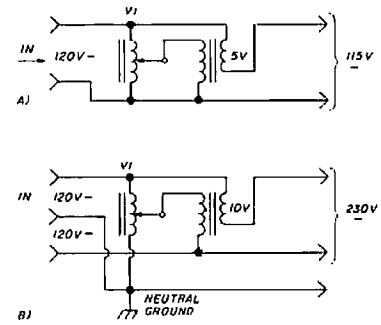


fig. 2. (A) Variable voltage transformer (V1) used on 120-volt circuit to adjust line voltage. (B) Variable voltage transformer (V1) on 240-volt circuit. Capacity of variable voltage transformer is equal to line current drawn by amplifier times difference in input and output voltages. For 2-kw condition (i = 14A) capacity is 14 × 10 = 140 watts.

a "cheap and dirty" antenna current indicator

Remember those good old thermocouple rf meters of yesteryear? Just the thing for measuring antenna current! You can occasionally find one at a flea market, but if you can't, Jack Sobel, WØSVM, has a satisfactory substitute for all except nitpickers (**fig. 3**). Jack shunts a No. 47 pilot lamp with a 33-ohm, 1-watt resistor. This little assembly has copper alligator clips on it and he snaps it across a few inches of his feedline at his antenna tuner. He uses two of these gadgets for a two-wire line. Vary the tap spacing to accommodate your power level.

the helix antenna revisited

The helix dipole seems to generate

more heat than light. A lot of hams don't like them, but some who have used them are very happy with them. Bruce Muscolino, W6TOY, has used helix-wound antennas for some years.

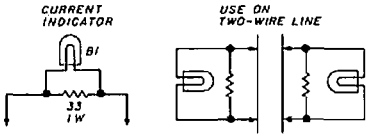


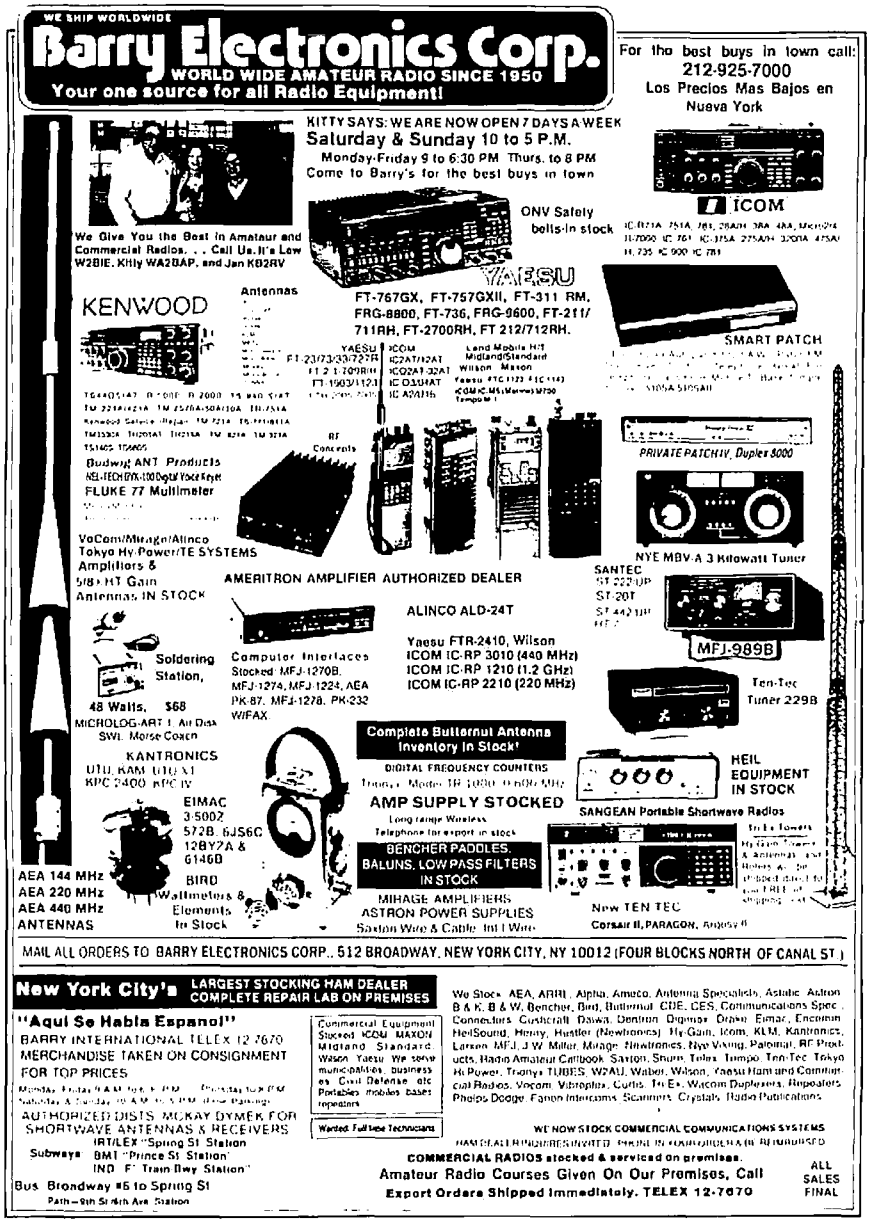
fig. 3. Inexpensive antenna current indicator. Clips are placed across a few inches at one feed wire. Vary resistance value to match line circuit. (Design shown is for two-wire line.)

One arrangement he found satisfactory was two HY-gain helically wound fiber glass CB antennas which he used back-to-back as a helical dipole, hung in his small attic. A hand-wound center coil resonated them to 20 meters with the aid of a dip meter. He fed the antenna with ribbon line and an antenna tuner. Running 100 watts, he made WAC over a period of several weeks. For those Amateurs who have landlord problems, a simple antenna like this may be the only compromise which permits them to get on the air!

what to do when the band is dead

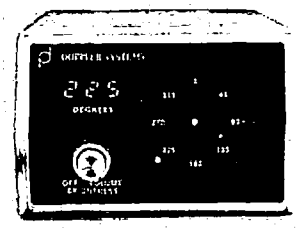
What do you do when the band is dead? Many times I hunker down with a good book and forget Amateur Radio. I have favorites that I have read repeatedly over the years. I bet you do too! Just to see how smart my readers are, I'm going to give you a quotation from one of my favorite books and see how many can identify it. No prizes, but I'll give the name and call in this column of the readers who send their QSL card to me (Box 7508, Menlo Park, California 94025) with the name of the book and the correct identification of the quote. Choice of the "winner" will be arbitrary-HI. OK? Here's the quote: "You have been in Afghanistan, I perceive."
(That was easy, wasn't it?)

ham radio



Barry Electronics Commercial Radio Dept. offers the Best in two-way communications for Businesses, Municipalities, Civil Defense, Broadcasting Companies, Hospitals, etc. Sales and Service for all brands: Maxon, Yaesu, Icon, Tad, Octagon, Regency/Wilson, Midland, Standard, Uniden, Shinway, Fujitus, Seas, Spillsbury, Neutec, etc. Call or write for information. 212-925-7000.

INTERFERENCE?



★ Interference Location
★ Stuck Microphones
★ Cable TV Leaks
★ Security Monitoring

★ VHF and UHF Coverage
★ Computer interface
★ Speech Synthesizer
★ 12 VDC Operation

New Technology (patent pending) converts any VHF or UHF FM receiver into an advanced Doppler shift radio direction finder. Simply plug into receiver's antenna and external speaker jacks. Uses four omnidirectional antennas. Low noise, high sensitivity for weak signal detection. Call or write for full details and prices.

DOPPLER SYSTEMS, INC. P.O. Box 31819 Phoenix, AZ 85046 (602) 488-9755

2-meter monitor

A simple receiver project

Are you looking for a simple club project? How about a spare 2-meter receiver? A receiver to take backpacking? A scanning receiver for those times on the road? A digital data link? Radio control receiver? Direction finding receiver? Here's one that's hard to beat for simplicity and performance. One or two evenings and a little searching in the old junk box is all it takes.

When's the last time you fired up the old soldering iron? A friend of mine once said, "Rosin is the grease paint of our industry and every now and then you've got to get out to the bench and remember what it is to smell some solder."

Thanks to a new product line from Motorola, which includes narrowband fm transmitters and receivers, this dual conversion tunable receiver is about as simple as a receiver can get.

MC3362

The receiver is built around the new Motorola MC3362. Although there have been a few "receivers on a chip" (like the CA3089) for a few years, none comes close to the MC3362. Until now most ICs have included the i-f amplifiers, detectors (or discriminators), and audio pre-drive circuits. The MC3362 is a dual conversion receiver that starts at the antenna and ends at the audio output.

A basic block diagram of a dual conversion receiver is shown in **fig. 1**. Notice that the antenna feeds directly into the first mixer with no rf stage. This technique is more common than most people realize. RF amplifiers are included only in high performance rigs. If you have a fully synthesized 2-meter rig it probably has one, but the difference in performance with or without an rf stage is minor. (Please, no letters from DX hounds with liquid nitrogen-cooled front ends!) Tests on the unit I built showed a sensitivity of about 1.5 microvolts — not fantastic but not bad either.

Except for the i-f filters, the crystal, the audio driver, some resistors, capacitors, inductors, and the speaker, the MC3362 has all of the circuitry shown in **fig. 1**. The MC3362 specifications are listed in **table 1**.

A functional block diagram and pinouts of the MC3362 are shown in **fig. 2**. Let's take a look at it block by block.

first mixer

The first mixer has two inputs in case you want to use a balanced drive from a transformer. Motorola says this mixer is good to about 470 MHz. Input required at 49.7 MHz (the IC was built for the cordless telephone market) is typically 0.7 microvolt for an (S + N)/N of 20 dB. Gain is about 18 dB; Motorola says this increases to about 2 microvolts at 470 MHz.

first LO

The first local oscillator can use an LC tank or crystal as its frequency determining element, or an external source. In the case of an LC tank, a varicap diode is included so that tuning can be accomplished by using a variable control voltage instead of a variable capacitor. If you need a wide tuning range, use a large inductor and small capacitor in your tank so that the varicap has more effect (the varicap range is about 10 to 20 pF). Coarse tuning can be accomplished by tuning the capacitor in the tank (pins 21, 22), fine tuning

By Rodney A. Kreuter, WA3ENK, 319 McBath Street, State College, Pennsylvania 16801

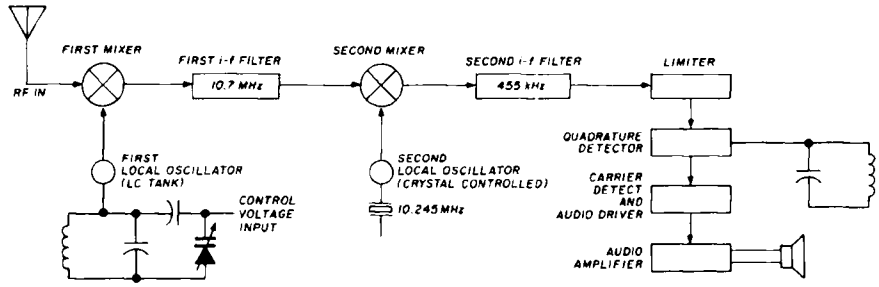


fig. 1. Block diagram of a typical dual conversion FM receiver.

Table 1. MC3362 specifications

First i-f	10.7 MHz
Second i-f	455 kHz
Power Supply	2 to 7 volts (regulated)
Current Consumption	4 mA
Sensitivity	0.7 microvolts (50 MHz)
Maximum Frequency	180 MHz (with internal LO) 470 MHz (with external LO)
First Mixer Input	690 ohms in parallel with 7.5 pF
Cost	$1.86 in 100-piece quantity (Sept. 1987)

by using the varicap. Keep the control voltage between 1.2 volts and V_{CC}, the supply voltage. The oscillator quits below about 1.2 volts. If you don't use the varicap, tie pin 23 to V_{CC}.

Maximum frequency is about 180 MHz. Use a larger V_{CC} for higher frequency operation.

A buffered output is provided for this LO (pin 20), in case you want to phase lock it to an external source. *Be careful not to ground this pin* because it is the emitter of an emitter follower with no collector resistance.

first i-f

The first i-f filter is external to the MC3362. A 10.7-MHz ceramic filter is recommended. The muRata filter that Radio Shack used to carry is satisfactory. Note that many different filters will work here: the main considerations are bandwidth, insertion loss, and cost. Be careful — some 10.7-MHz filters are not 10.7 MHz, but more like 10.63 MHz. Impedance should be 330 ohms. Typical parts are the muRata SFE10.7MA and Toko SK107M3-AO-10.

second mixer

The second mixer also has two inputs, perhaps to accomodate a fancy 455-kHz crystal filter that requires transformer matching. The gain is about 21 dB; response is good to about 20 MHz.

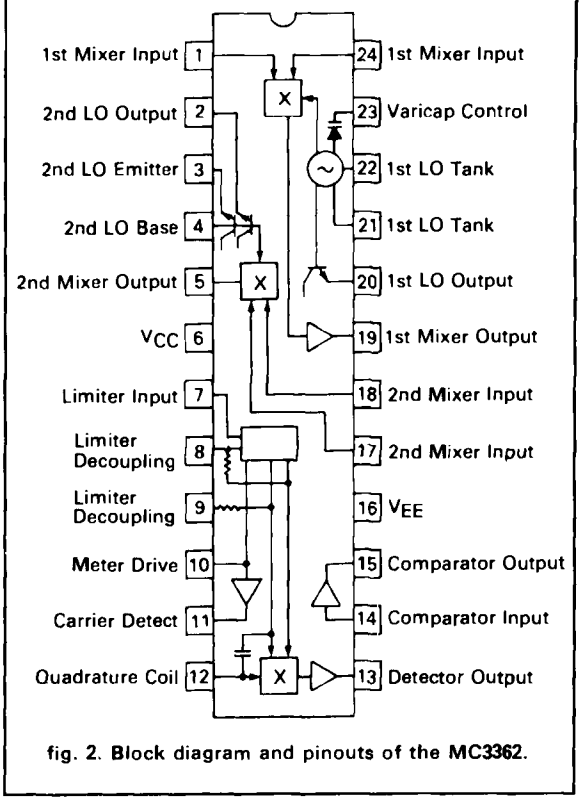


fig. 2. Block diagram and pinouts of the MC3362.

second LO

The second local oscillator is designed to be crystal controlled at 10.245 MHz (10.7 MHz—455 kHz). The crystal should be a fundamental type cut for a load capacitance of 32 to 40 pF. A buffered output is provided (pin 2).

second i-f

The second i-f filter is external to the MC3362. A 455-kHz ceramic filter is recommended. The printed

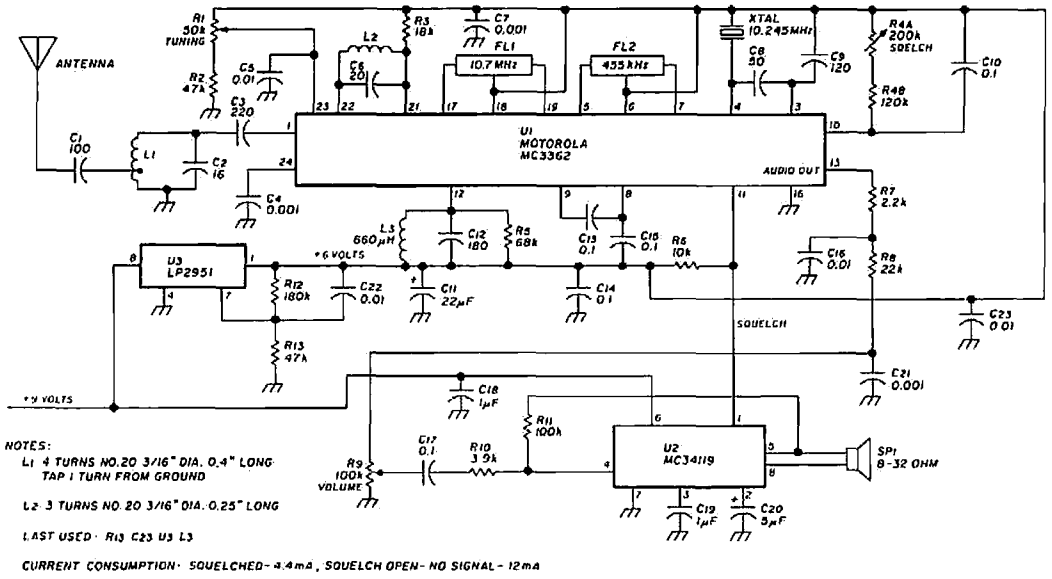


fig. 3. Motorola MC3362 IC is foundation for 2-meter receiver.

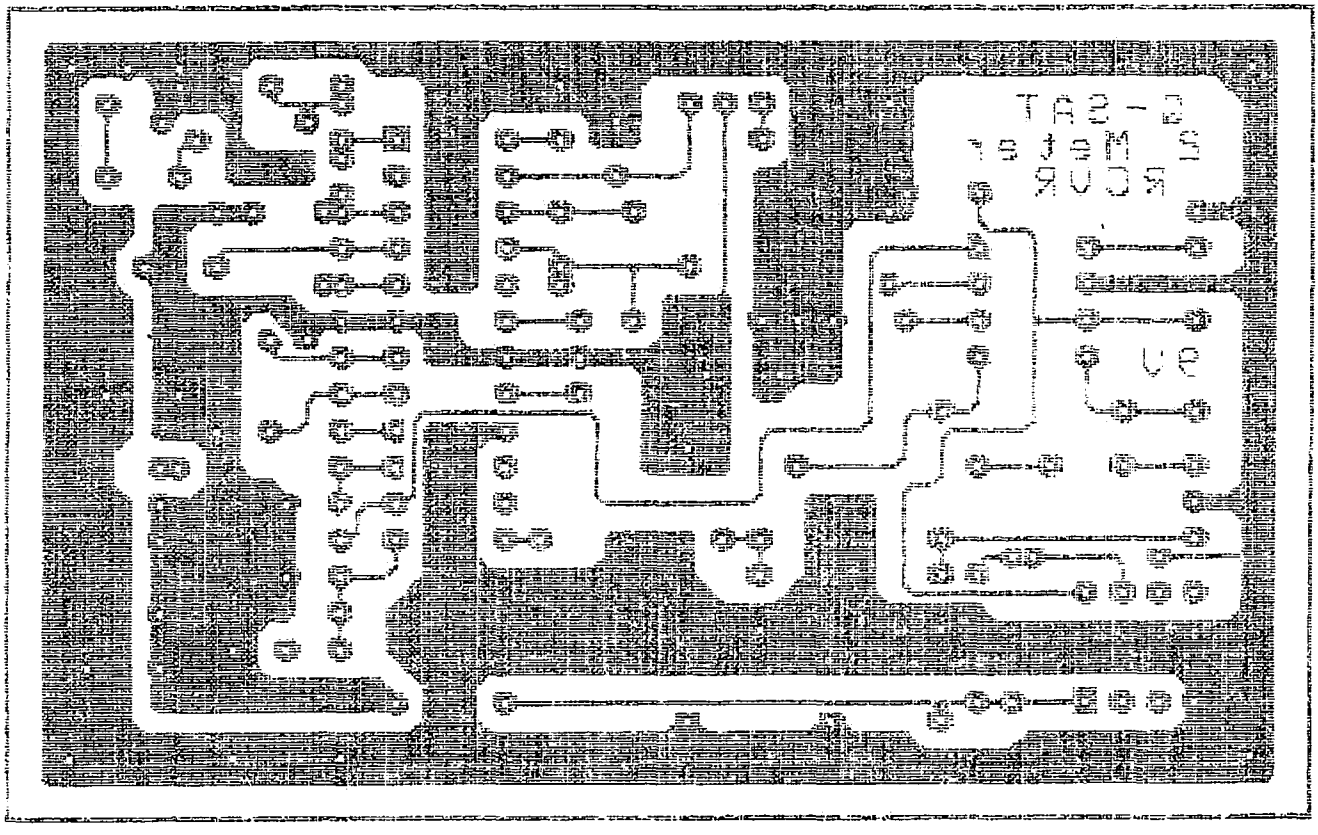


fig. 4. Printed circuit artwork; 2X size. Top view looking through the board.

parts list

C1	100 pF
C2	16 pF NPO or dipped silver mica (see text)
C3	220 pF
C4,C7,C21	0.001 μF
C5,C16,C22,C23	0.01 μF
C6	22 pF NPO or dipped silver mica (see text)
C8	47 or 50 pF
C9	120 pF
C10,C13,C14, C15,C17	0.1 μF
C11	10 to 22 μF, 10 volts
C12*	180 pF or RMC2A6597HK (see text)
C18,C19	1 μF
C20	5 μF, 15 volts
FL1*	10.7-MHz filter—SFE10.7MA (see text)
FL2*	455-kHz filter—SFU455A (see text)
L1	3/16 inches diameter 4 turns spaced to 0.4 inches tapped 1 turn from ground No. 20 wire
L2	3/16 inches diameter 3 turns spaced to 0.25 inches No. 20 wire
L3*	660 μH or RMC2A6597HK (see text)
R1	50-k pot
R2	47 k (see text)
R3	18 k
R4	(see text)
R5	68 k
R6	10 k
R7	2.2 k
R8	22 k
R9	100-k pot (audio taper)
R10	3.9 k
R11	100 k
R12	180 k
R13	47 k
U1*	Motorola MC3362P
U2*	Motorola MC34119P
U3*	National LP2951CN
Crystal*	10.245 MHz (HC-18U style)
Printed Circuit Board*	

All capacitors should be as small as possible.

All resistors 1/4 watt.

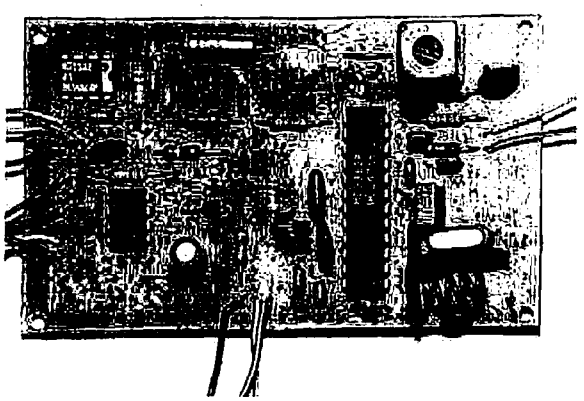


fig. 5. Closeup of 2-meter receiver showing parts placement.

circuit board is laid out to accept two different pinouts. The 455-kHz filters once sold by Radio Shack will work. As in the case of the 10.7-MHz filter, consider bandwidth, loss, and cost. Impedance should be 1.5 to 2 k. Typical parts are the muRata CFU455D and SFU455A, and the Toko LFC-455I.

A limiter is used to remove any a-m component from the signal. The limiter response is good to about 1 MHz.

A quadrature detector is provided to detect the fm signal. Output is dependent on the carrier "swing". Figure about 250 microvolts for narrowband fm.

A meter drive and a squelch circuit are provided.

Data detect is a comparator which is designed to detect zero crossings of FSK modulation data rates of 2000 to 35000 baud.

construction

The basic receiver circuit is from a Motorola application note. It was so new that it didn't have an application note number. The schematic (modified from the application note) is shown in **fig. 3**.

Since the receiver is operating at 147 MHz, it is advisable to build the circuit on a pc board (**fig. 4**). Perfboard with a ground plane and some copper tape can be used; my original prototype was built on a Radio Shack board — the type with a ground plane on top.

If you duplicate the pc board presented here, please note that some capacitors have more than two mounting holes. Don't worry about the extra holes; just find the best fit (**fig. 5**). Be careful — it's crowded around L_1!

Some things about this circuit may seem a little strange. For example, if you've ever used ceramic filters, you probably connected the middle lead to ground instead of to the V_{CC} plane. Actually, at 150 MHz and with proper power supply bypassing, the V_{CC} plane and the ground plane are both at the same ac potential, so it doesn't really make any difference. Also many components that you would normally see connected between the IC and ground are really connected to the V_{CC} plane.

The voltage regulator (a National LP2951) used in this design is also a little different; it's a low dropout adjustable regulator. Believe me, I agonized over using this part because many people will have a hard time obtaining it. Why not just stick to a 7805? Most regulators require an input voltage at least 2 volts higher than the output. For example, imagine a standard 5-volt 7805 operating from a 9-volt NiCd battery. In the first place, a 9-volt NiCd is really 8.4 volts. Since the 7805 requires about 2 volts more than the output, this circuit will work until the battery output falls to about 7 volts. With the LP2951, the circuit will work until the battery falls to about 5.5 volts. (Battery life is extended by using the LP2951.)

The output may be trimmed to suit your power supply. Because Motorola suggests a slightly higher voltage for operation at 150 MHz, an adjustable regulator is recommended. The temperature performance of this particular part is better than almost anything else on the market. You probably can delete it (jumper pin 1 to pin 8) and get away with four AA batteries for a power supply, but I suggest a 9-volt NiCd and a regulator. Motorola warns that the first LO will drift with any change of the power supply.

The audio amplifier is a bit different, too. I've used

Directory of component manufacturers

muRata-Erie 1148 Franklin Rd, S.E. Marietta, Georgia 30067	(404) 436-1300 coils, crystals, ceramic filters, crystal filters
Toko America Inc. 1250 Feehanville Drive Mount Prospect, Illinois 60056	(312) 297-0070 coils, ceramic filters, crystal filters, quadrature coils
Coilcraft 1102 Silver Lake Road Cary, Illinois 60013	(312) 639-6400 coils
Fox Electronics PO Box 1078 Cape Coral, Florida 33910	(813) 482-7212 crystals
GTE Sylvania Electronic Components Division 2401 Reach Road Williamsport, Pennsylvania 17701	(717) 326-6591 crystals
International Crystals P.O. Box 26330 Oklahoma City, Oklahoma 73126	(405) 236-3741 crystals
JAN Crystals P.O. Box 06017 Ft. Myers, Florida 33906	(813) 936-2397 crystals
Comtec 3300 East Sparrow Ave. Flagstaff, Arizona 86004	(602) 526-4123 crystals
Standard Crystal Corp. 9940 E. Baldwin Pl. El Monte, California 91731	(818) 443-2121 (800) 423-4578 crystals
Digi-Key Corp. P.O. Box 677 Thief River Falls, Minnesota 56701	(800) 344-4539 Toko coils and filters

For the National Semiconductor and Motorola parts, I suggest you contact your nearest sales office or try the following distributors: Hamilton—Avnet, Hallmark, Schewber, or Mil-Gray.

the LM386 in this type of application for quite a while, but I hate finding room for a 100- or 250-μF output coupling capacitor. The MC34119 with a differential output and an enable pin is hard to beat.

Notice resistors R_{4A} and R_{4B}. If you want an adjustable squelch, use them both ($R_{4A} = 200$ k; $R_{4B} = 1$ k). If you'd rather have a fixed level, replace R_{4A} with a jumper and make R_{4B} about 120 k. The pc layout is set up for either configuration.

Inductor L_3 and capacitor C_{12} can both be replaced by a Toko LC tank part number RMC2A6597HK (highly recommended). If the tank doesn't seem to want to go down far enough in frequency, put about 18 pF in parallel with it.

If you can't find nonpolarized capacitors for C_{18} and C_{19}, use polarized caps. In both cases the negative side will go to ground.

The only critical thing about this circuit is that you enjoy building it!

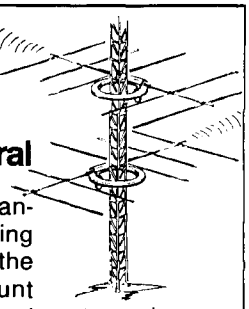
tune-up

I suggest that you omit C_2 and C_8 at the start. In my first prototype I calculated the coils precisely and allowed for input capacitance, strays, and the varicap. They weren't even close (10 MHz off). As an alternative, tack solder a trimmer (10-60 pF) temporarily to the bottom of the board. Tweak the tank using the trimmer; then take the tank out and measure it. Substitute the closest cap you can find.

Your tune-up can be done in a number of different ways. Some signal source will be necessary. A signal generator is best, but you can use a grid dip meter or an on-the-air signal like a busy local repeater. Start with the first LO tank (L_2, C_6). For now, you can tack a trimmer capacitor in place of C_6, or squeeze and stretch the coil until the oscillator is around 136 MHz. The buffered output and a frequency counter would be ideal. After you have trimmed the oscillator tank, you can tune the input coupling tank (L_1, C_2) using the same method. Now tune the quadrature coil L_3. Don't forget the tuning control R_1 during all this. By the way, increasing R_2 will give a smaller, less critical tuning range. Just don't go below 10 k or the control voltage will drop below 1.2 volts. A practical upper limit is probably about 100 k.

My prototype tuned 4.5 MHz (143.75 to 148.25

NETWORK SERIES 1000 ™
The Original Ringrotor



NEW FROM TIC General

Here's a fantastic new idea in antenna rotators? Instead of rotating one antenna per tower, with the Network 1000, you can mount several antennas on a tower and rotate each one either together in a phased array, or independently of each other.

Uses high strength steel gear drive, super strong I-beam ring construction and has been fully field tested. You can also aim the antenna to 1 degree of accuracy. TIC also has a digital control box available.

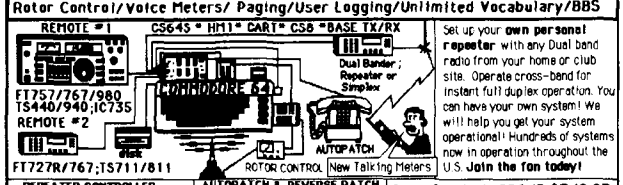
For more information about this exciting new antenna rotator, call TIC today.

(800) 423-6417 nationwide, **(800) 542-5009** MN
or **(218) 681-1291 or write**
TIC General, P.O. Box 1
Thief River Falls, MN 56701.

Be the envy of your club
when you demonstrate your new
TIC Network 1000!

162

*** Super Comshack 64 ***
Programable Repeater Controller/HF & VHF Remotes/Autopatch
Rotor Control/Voice Meters/ Paging/User Logging/Unlimited Vocabulary/BBS



Set up your **own personal repeater** with any Dual band radio from your home or club site. Operate cross-band for instant full duplex operation. You can have your own system! We will help you get your system operational! Hundreds of systems now in operation throughout the U.S. **Join the fun today!**

REPEATER CONTROLLER
*Change all variables remotely
*Synthesized voice adj.pitch/speed
*Program mail box or select ID
tell mess. with touchtones from HT
*Alarm clock & auto excute mode
*Macro commands/user **logging**
*Individual user access codes
*Code practice & voice readback
*Multifunction voice alarm clock
H.F. REMOTE #1
***20 Macro mem**/auto mode sel
*Scan up/down sel. rate or step
*Voice ack. all control commands

AUTOPATCH & REVERSE PATCH
***1000** (**18** digit)tel. #'s stored
***300** users/CTCSS & 2 tone paging
***50** enable/disable tel #'s
*Directed/general & reverse page
*Userprogams Tel. answer message
*Full or Half duplex (level cont.)
*Security mode/ TT readback on/off
*Store MCI/Sprint tel. #'s
*Reverse Patch active all modes
*Call waiting/quick dial & reset
V.H.F. REMOTE #2
*Dual VFO's/ Rev/Split/COR detect
*Set Scan inc. & offset/var. resume

Super Comshack CS645 $349.95
+ $4.00 ship USA; incl. computer interface, disk, cables & manual (simplex version inc. on request)

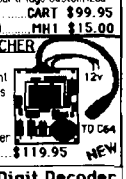
SYSTEM OPTIONS
*External Relay Control 3 DPDT relays + 5 open collector outputs..**CS-8$79.95**
*Beam control; speaks bearing and rotates beam ,1 degree incre. **HM1 $49.95**
*2 Voice Meter & Alarm inputs/8 Ext. On/off controls/Packet BBS. **PK8 $149.95**
*EPROM Auto boot Cartridge customized with your system .....**CART $99.95**
*Manual (Refunded).....**MN1 $15.00**

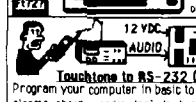
MINI (BEAR CAT) COMPUTER CONTROL FT-727R
Programs and Scans 100 ch. in Ham/General coverage. Converts it into a powerful **100 ch. scanner** & programs all for field use!



*Digital "S" meter, stops scan from S(1-9). Auto resume
*Loads & programs all FT-727R parameters in less that 15 secs
*Includes hardware & disk for C64 or IBM PC MODEL727S **$39.95**

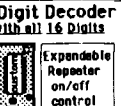
12v C64 SWITCHER
*Draws 1.1A @12v
*70khz 75% efficient
*Outputs 5v @2 amps and 9 vac 60Hz
*Crystal time base
*Plugs into C64 power
MODEL DCPS.....**$119.95**





Touchtone to RS-232 (300 baud interface)
Program your computer in basic to decode multidigit "strings", sound alarms, observe codes, includes basic program for C64 VIC20/C128; **works on all computers!**
MODEL DAP **$89.95**

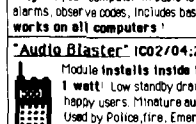
Touchtone 4 Digit Decoder
& on/off latch with all 16 Digits



Expendable Repeater on/off control

*Low power CMOS +5 to +12 Volts
*User programable **50,000**, 4 digit codes
*Send code once to turn on, again to turn off
*Momentary & Latch output drives relay
*Wrong digit reset; no falsing; 2 to 4 digits
*Mute speaker audio until call is received
*LED displays latch state; Optional 4 digit extra custom latch.(7225) IC's $6.95 ea
***Model TSD $59.95**

"Audio Blaster" IC02/04;2A1;U16;FT209/727;23/73R
Module **installs inside the radio** in 15 Min. Boost audio to **1 watt!** Low standby drain/Corrects low audio/1000's of happy users. Miniature audio amplifier --> Used by Police,fire, Emergency, when it needs to be **HEARD!**



NOW FOR FT75/25R ORDER MODEL AB1-6 $22.95
MODEL AB1 **$19.95**

ENGINEERING CONSULTING ** 583 CANDLEWOOD ST. BREA, CA. 92621**
MASTERCARD ** VISA ** CHECK M.O. ** CA. RES. ADD 6% TEL: 714-671-2009**

MHz) with the parts called for in the parts list. For fine tuning add a 5-k pot between R_1 and R_2, connected as a variable resistor; or better yet use a ten-turn pot for R_1.

modifications

There is no reason that this receiver must work on 2 meters. Motorola doesn't specify the lower operating frequency, but I suspect it will go all the way down to the a-m broadcast band. Of course, a narrowband fm receiver isn't much good below 28 MHz. It was designed to operate on 49 MHz, and 6 meters should be no problem. (My prototype is also a good weather receiver on 162 MHz.)

Because tuning can be done using a control voltage, a scanner seems to be a natural. A ramp generator or even a counter with a D/A can be connected to pin 23. The squelch can be used to stop the scan. Remember not to allow the control voltage to go too low.

With a fixed crystal instead of an LC tank for the first LO, you could operate on the 75-MHz radio control band — if fm is allowed on that band. Motorola's data sheet covers operation with a fixed crystal oscillator, although it's a bit sketchy.

more Motorola parts

In addition to the MC3362, Motorola has three more ICs which should be of interest to hams. One is the MC3363 narrowband fm receiver. This receiver is much like the MC3362 but has an extra NPN transistor and an op-amp. It's available only in a 28-pin surface mount package.

The MC2831A, a low-power fm transmitter, includes a microphone preamp, fm modulator, rf buffer good to 30 MHz, a tone oscillator, and a low battery detector.

The MC2833 fm transmitter is the same as the MC2831A, but has no tone oscillator or low battery detector. It does have two undedicated NPN transistors which can be used as rf amplifiers or doublers/triplers. (24 MHz multiplied by 6 puts it on 2 meters.) It might make a nice transceiver with the MC3362.

obtaining parts

Parts seem to be a problem these days. The people at Motorola were nice enough to provide me with the lists of parts suppliers.

You can obtain a printed circuit board for $6 plus $1 postage and handling. A kit of "hard to find" parts (marked with an * on the parts list) is also available for $23 plus $2 postage and handling from: Q-Sat, PO Box 110, Boalsburg, Pennsylvania 16827. (Pennsylvania residents please add 6 percent sales tax.)

ham radio



all-new TM-721A FM dual bander

Kenwood's new FM Dual Bander includes a dual channel watch function, selectable full duplex operation, 30 multifunction memory channels, extended frequency coverage, large multicolor digital LCD displays, programmable scanning, with 45 watts of output on VHF and 35 watts on UHF.

Other features include:

- Extended receiver range (138.000-173.995 MHz) on 2 meters; 70 cm coverage is 438.000-449.995 MHz. (Specifications guaranteed on Amateur bands only. Two-meter transmit range is 144-148 MHz. Modifiable for MARS/CAP. Permits required.)
- Fourteen memory channels and one call channel for each band store frequency, repeater offset, CTCSS, and reverse. Channels "A" and "b" set upper and lower limits for programmable band scan. Channels "C" and "d" store transmit and receive frequencies independently for "odd splits".



- Dual frequency display for "main" and "sub-band."
- Automatic Band Change (A.B.C) changes between main and sub-band when a signal is present.
- Dual watch function allows VHF and UHF receive simultaneously.
- Handset/remote control option (RC-10).
- Dual antenna ports.
- Programmable memory and band scanning, with memory channel lock-out and priority watch function.
- Supplied accessories: 16-key DTMF hand microphone, microphone hook, mounting bracket, and dc cable.

The suggested retail price is $649.95. For details see your Kenwood dealer or write Kenwood USA Corporation, Communications and Test Equipment Group, 2201 E. Dominguez Street, Long Beach, California 90810.

new edition listeners catalog

Universal Shortwave has released a new edition of their listeners catalog. Catalog 88-03 has a full line of portable and communications receivers, antennas, headphones, books, and accessories. As always, a large section of the catalog is devoted to radioteletype and facsimile equipment.

Universal's Amateur Radio division has just published its first ham radio catalog. Catalog 88-02 features a full spectrum of Amateur equipment, representing all major manufacturers.

Both catalogs are now available for $1 each (refundable) or free with any purchase from: Universal Radio, 1280 Aida Drive, Reynoldsburg, Ohio 43068.

Circle #301 on Reader Service Card.

Kantronics Watchdog and Morse Tutor

Kantronics announces the Watchdog circuit that can be installed inside the KPC-1, KPC-2, and the KPC-400. The circuit monitors the push-to-talk line of the TNC. If the P.T.T. has been active for two minutes, the Watchdog will activate and the attached radio will un-key preventing a local area network from being disabled due to a "hung-up" TNC. After the circuit has been activated, a power on/off will restore the KPC to normal operation.

The Watchdog circuit retails for $10, plus $2.50 for shipping in the U.S. and Canada. International shipping is $7.50.

The new Kantronics Morse Tutor for IBM compatible computers provides practice, quiz, and general information functions. It has alternate learning sequences and variable character speeds to sound like hand-sent code. No memorization of commands is required to operate.

The Morse Tutor is priced at $19.95, plus $2.50 for shipping in the U.S. and Canada. International shipping is $7.50.

For more information contact Kantronics, Inc., 1202 East 23rd Street, Lawrence, Kansas 66046.

Circle #302 on Reader Service Card.

satellite tracking, propagation software

Randy Stegemeyer, W7HR, has developed a new satellite tracking software package for Macintosh computers with at least 512K RAM and an 800K drive. MacTrak offers tabular data output for tracking and scheduling, and "windows" to selected locations. Graphics capabilities include world map, polar, and great circle displays. A view mode presents the earth as seen at any time from the satellite. The real-time mode displays data as it changes and, when used with the KLM/Mirage Tracking Interface, follows satellites as they pass within range. The program also tracks the sun and moon and would be useful for EME applications.

A propagation prediction package is included which provides an estimate of Maximum Usable Frequency (MUF) to any point, calculates sunrise and sunset times, bearings and distances, and displays the "gray line".

The program is priced at $49.95. For complete details contact the author at PO Box 1590, Port Orchard, Washington 98366.

new version 4.4 software for CS64S

Engineering Consulting has introduced new 4.4 software for the Super Comshack 64 Model CS64S for the ham shack or hilltop repeaters.

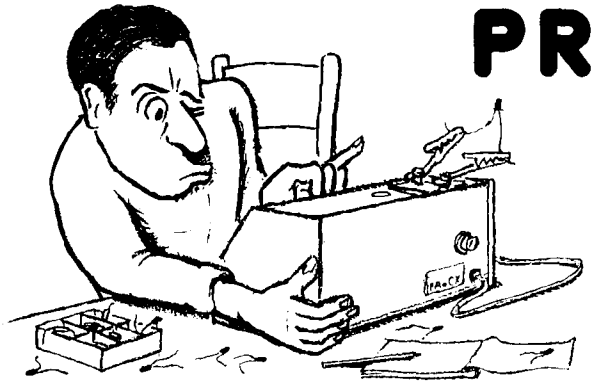
Each user may be assigned a unique access code which the Super Comshack 64 recognizes. The control operator can then allocate access privileges on various levels of system control. The Super Comshack system "speaks" the call-sign of each station requesting access to a function such as autopatch, remotes, or system commands.

The new version 4.4 software supports up to 300 users and up to 1,020 18-digit telephone numbers which can be assigned to individuals in banks. New users may be added to the system at any time.The system can be reprogrammed remotely to switch over to nine sets of parameter files, each containing unlimited system variables. A complete printout of user assignments and all parameters can be made at any time.

The control operator can adjust the speed and pitch of the voice synthesizer. The new software has the capability to pronounce all words in the English language. Verbal messages can be entered from the parameter files or from touchtones; emergency messages can be created from touchtone strings which represent letters.

The version 4.4 software can be used with any REV 4 CS64S board. It is available from Engineering Consulting, 583 Candlewood Street, Brea, California 92621 for $59.95, which includes the manual and 90-day free revision upgrades.

SAY YOU SAW IT IN HAM RADIO



PRACTICALLY SPEAKING

Joe Carr, K4IPV

non-ideal linear IC amplifiers typical problems and how to solve them

Operational amplifiers and other linear IC devices are widely used in communications equipment; this includes Amateur equipment. Unfortunately, the textbook circuits are based on ideal devices — amplifiers that are perfect in every way. That little ploy makes the equations work, but is somewhat naive for the real world. When you go to the electronics parts store (or mail-order catalog), the kind of op-amps you'll find fall short of the ideal type in the textbooks. Here's a dose of reality — and the medicine needed to correct the problems that these amplifiers exhibit.

We'll consider two major problems. The first is dc offsets on the output resulting from any of several defects, the different forms of offset, and several means for eliminating them. Second, we'll discuss the problem of frequency response. This problem is twofold, involving gain bandwidth product (which affects the maximum frequency response of the circuit) and excess frequency response. The latter can lead to oscillation and ringing in the output circuit.

dc offset problems

A dc output offset is a dc voltage that appears on the output terminal, but not in response to any input signal. It's an output voltage that exists when it shouldn't (i.e., when $V_{in} = 0$). There are several sources of output offset voltage in real-world op-amps.

Input Offset Current. One cause of the output offset voltage is input offset currents. **Figure 1** shows the typical input stage used in bipolar op-amps. Transistors Q1 and Q2 form an NPN differential pair. The inputs of ideal op-amps neither sink nor source current, but real op-amp inputs are transistors — and transistors need to be biased. If this were an ideal world the two currents would be equal and cancel out. But real op-amps use transistors that are mismatched ever so slightly. The differential input bias current forms an input offset current:

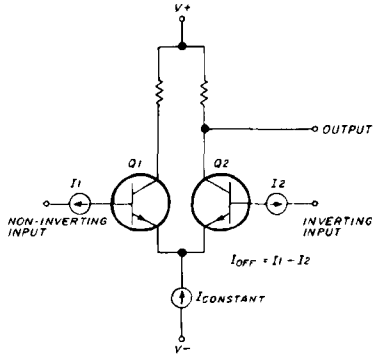


fig. 1. Differential amplifier input stage.

$$I_{off} = I1 - I2 \qquad (1)$$

The offset current (I_{off}) can produce an output voltage offset equal to the product of the current and the gain of the op-amp. While a low-gain op-amp circuit may not exhibit a large output offset from the input offset current, high-gain circuits almost invariably suffer such problems.

The severity of the problem depends in *part upon the design of the op-amp.* While certain old-fashioned types (like the 741) have rather significant offset currents, certain new types have the current reduced to a point where it is all but negligible. Especially low-input bias currents are found in op-amps that use either MOSFET or JFET transistors for input transistors Q1 and Q2 (**fig. 1**). These devices are called Bi-MOS and BiFET op-amps, respectively.

One problem with input offset currents occurs when a feedback network is used to set the gain of the op-amp (including both inverting and noninverting followers). The current flows in both input resistor (R1) and feedback resistor (R2), and produces an input offset voltage equal to the product of the current and the parallel combination of R1 and R2. By Ohm's law, this voltage is equal to:

$$V = \frac{(I_{B1} \cdot R1 \cdot R2)}{(R1 + R2)} \qquad (2)$$

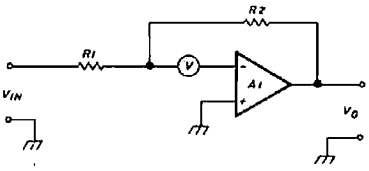


fig. 2. Input offset voltage.

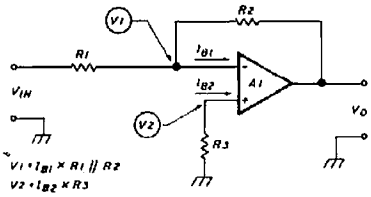


fig. 3. Use of compensation resistor.

A method to cancel this voltage in practical circuits by using a compensation resistor in series with the other (noninverting) input follows.

Input Offset Voltage. The ideal op-amp has no voltage sources in series with either input, except those external sources that supply signal. Real op-amps, however, have an internal voltage source in series with one or both inputs. The input offset voltage **fig. 2** is defined as the voltage required to force the output voltage to zero when the input signal voltages are zero. There are usually independent voltages in series with each input, but unless they are exactly equal (in which case they cancel each other), we can model the input offset voltage as a single voltage source in series with one of the two differential inputs. The output voltage offset produced by the input offset voltage is given by:

$$V_{out} = \frac{(V)\,(R1 + R2)}{R1} \qquad (3)$$

Where:
V_{out} is the output offset voltage at V_o in **fig. 2**
V is the input offset voltage
R1 is the input resistance
R2 is the feedback resistance

corrections for dc offset problems

Both input offset current and input offset voltage produce an output offset voltage that can adversely affect amplifier operation. There are several ways to eliminate the output offset voltage.

Figure 3 shows an inverting follower circuit that uses a compensation resistor (R3) to eliminate the output offset voltage caused by the input offset current. The input bias current flowing from the inverting input (IB1) will create a voltage drop (V1) across R1 and R2. This voltage was defined in **eqn. 2.** Voltage V1 is seen by the op-amp as a valid dc signal voltage. If the value of R3 is equal to the parallel combination of R1 and R2, then the voltage drop across it (V2) will be the same as the voltage applied to the inverting input. In other words, V1 = V2. This situation occurs because the two bias currents are almost equal in the majority of op-amps. The value of R3 is the parallel combination of R1 and R2, or:

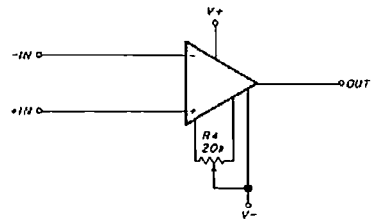


fig. 4. Use of offset null terminals on some op-amps.

$$R3 = \frac{R1 \cdot R2}{R1 + R2} \qquad (4)$$

Figure 4 shows the use of built-in offset null terminals found on some op-amps (typically pins 1 and 5, or 1 and 8). This circuit can eliminate output offset voltages from any source. The offset null potentiometer is connected between the offset null terminals, while the potentiometer wiper is connected to the negative dc power supply (V−). This method is preferable where the offset voltage is within the normal range of the offset null terminals.

The variant circuit in **fig. 5** is used on the LM-101, LM-201 and LM-301 op-amps. In this circuit the potentiom-



SSB ELECTRONICS TRANSVERTERS

LT6S	50/28 MHz, 20W, GaAs-Fet, DBM	$529
LT2S	144/28 MHz, 20W, GaAs-Fet, DBM	529
LT70S	432/28 MHz, 20W, GaAs-Fet, DBM	549
LT33S	902/144 MHz, 20W, GaAs-Fet	549
LT23SO	1269/144 MHz, 10W, OSCAR	549
LT23S	1296/144 MHz, 10W, GaAs-Fet	549

MASTMOUNTED RF SWITCHED GaAs-Fet PREAMPLIFIERS

SP-2	144 MHz, 0.8DB NF, 25 DB Gain	199
SP-70	432 MHz, 1.0DB NF, 25 DB Gain	199

RF SWITCHED GaAs-Fet PREAMPLIFIERS

MX-2	144 MHz 0.8DB NF, 25 DB Gain	89
MX-70	432 MHz 1.0DB NF, 25 DB Gain	99

MISCELLANEOUS ITEMS

UEK-3	901 Or 1296 LO/RX Conv. Kit	119
USM-3	902 OR 1296 TX Mixer, 1.5W	129

EME ELECTRONIC

HF400	High Power Relay, 2KW at 144 MHz	129
HF2000/6	High Power Relay to 6 GHz	199

TRANSVERTERS UNLIMITED

T144/28	Transverter, 25W, GaAs-Fet	229
T220/28	Transverter, 15W, GaAs-Fet	249
PA23200	1296 2 Tube Water Cooled PA	299

* SALE ITEMS—END OF LINE—USED—DEMOS ETC

EME ELECTRONIC

PA33200	902 MHz 2 Tube PA, 200W Out	429
PA23150	1296 MHz 2 Tube PA, 150W Out	379
PA1325	2304 MHz 1 Tube PA, 25W Out	359

MICROWAVE MODULES

MMT144/28R	Transverter, GaAs-Fet, DBM	329
MMT1296/144	Transverter, 2W	249
MMC432/28S	Converter	69
MMS-1	Morse Talker	120

MUTEK MASTMOUNTED GaAs-Fet PREAMPLIFIERS*

GMFA144E	144 MHz 0.5 DB NF Sequencer	$99
GLNA432E	432 MHz 0.6 DB NF Sequencer	$99

SSB ELECTRONIC TRANSVERTERS

LT33SL	902/144 MHz, 6W, GaAs-Fet	399

MASTMOUNTED GaAs-Fet PREAMPLIFERS

MV144SD1	144 MHz, .5 DB NF, 25 DB Gain	159
MV902S	902 MHz, 9 DB NF, 18 DB Gain	169
DCW15A	Sequence Controller for MV144	55
DCW15A-23	Sequence Controller for MV902	65

GaAs-Fet PREAMPLIFIERS

DX144	144 MHz 0.4 DB NF, 25 DB Gain	109
DX220	220 MHz 0.5 DB NF, 25 DB Gain	109
DX432	432 MHz 0.3 DB NF, 20 DB Gain	159
DX902	902 MHz 0.5 DB NF, 23 DB Gain	159
DX1296	1296 MHz 0.5 DB NF, 23 DB Gain	159

MISCELLANEOUS

PA2310	1296 MHz PA, 1W in 10W Out	189
PM1300A	Terminating Power Meter 20 MW-20W	199
TPM-4	Wattmeter DC-12 GHz .3MW-.1W	299
K7001	432/144 Receive Converter, DBM	109
TV28-144	144 MHz Transverter Kit, 100mw	149
TV28-432	432 MHz Transverter Kit, 100mw	149

TRANSVERTERS UNLIMITED

BOX 6286 STATION A
TORONTO, ONTARIO
CANADA M5W 1P3
(416) 759-5562

1900-2300 EDT
MONDAY-THURSDAY
VISA

163

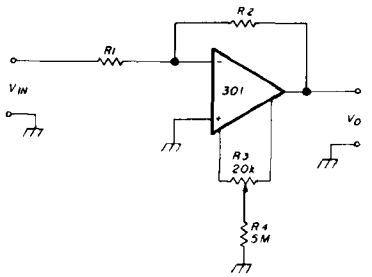


fig. 5. LM-101/LM-301 offset null terminals.

eter is connected across the offset null terminals as before, but the potentiometer wiper is connected to ground through a 5-megohm resistance (R4).

You should select a ten to twenty-turn trimmer potentiometer for any of these offset null circuits. This type of part allows maximum adjustability. The usual offset potentiometer is screwdriver operated, but if you use a shaft operated type you can use the same control as a position control for oscilloscopes, strip chart recorders, and other purposes where an offset is intentionally selected.

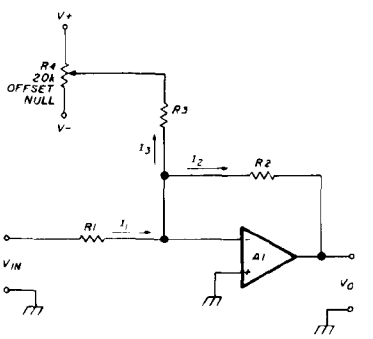


fig. 6. "Universal" offset null circuit.

Figures 6 through **9** show offset null circuits that can be used with any op-amp whether or not it possesses offset null terminals. The method shown in **fig. 6** is, perhaps, the most commonly seen. In this case, cancel the output offset voltage by inserting a counter current (I3) into the summing junction. When V1 is the voltage at the wiper of the offset null potentiometer the output voltage, due to the adjustment of R4, is:

$$V_O = V1 \cdot \frac{-R2}{R3} \qquad (5)$$

The idea is to adjust potentiometer R4 to obtain an output voltage that exactly cancels the output offset. For example, if the output offset potential is +1.5 volts, select a value of V1 that makes **eqn. 5** equal to −1.5 volts. In many cases, this involves making R3 = R2, so the voltage at the wiper of potentiometer R4 (i.e., V1) should be equal to the output offset voltage that it cancels.

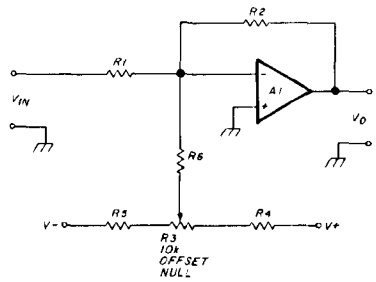


fig. 7. High resolution offset null circuit.

Figures 7 and **8** are variations on the same theme that permit better resolution adjustments of the offset voltage. These circuits are often used in high-gain amplifier circuits with small signals. Those applications typically have very low level signal inputs. The version in **fig. 7** places two resistors in series with the arms of the potentiometer (R4 and R5). The value of R3 is usually smaller than the combined values of R4 and R5, and also R4 = R5. The **fig. 8** version uses a pair of

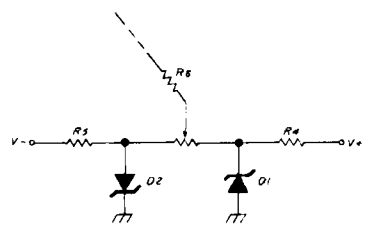


fig. 8. Alternate high resolution offset null circuit.

zener diodes to place the ends of the potentiometer at lower potentials than the V− and V+ voltages that operate the amplifier. In most cases the zener potentials of D1 and D2 are equal, giving a symmetrical range of offset voltages that can be canceled. There is no reason why different values can't be used if that is the situation of the specific circuit.

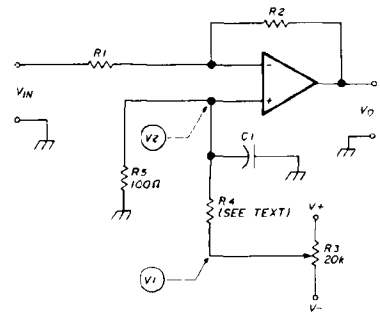


fig. 9. "Zero null" circuit.

Figure 9 shows a final offset null circuit. In this case, apply the counter-voltage to the noninverting input rather than the inverting input. A small value resistor (R5) is connected between the noninverting input and ground. A resistor from the potentiometer wiper (R4) acts with R5 to form a resistor voltage divider. The voltage applied to the noninverting input (V2) is:

$$V2 = \frac{V1 \cdot R5}{R4 + R5} \qquad (6)$$

or, given the value of R5:

$$V2 = \frac{100 \cdot V1}{R4 + 100} \qquad (7)$$

The output voltage produced by V2 acting on the op-amp's noninverting input is:

$$V_O = V2 \frac{R2}{R1} + 1 \qquad (8)$$

Because of the gain of the circuit, make V2 a very small value. Use the equations above to select the values for V1 and R4 required to cancel out the offset voltage.

The capacitor used between the inverting input and ground is optional in most cases. C1 sets the noninverting input at ground potential for ac signals, while keeping it at a non-zero value of V2 for dc. The value of C1 is such that it has a capacitive reactance of 10 ohms at the lowest frequency of oper-

ation. This capacitor can be used only in relatively low gain circuits because capacitors to ground from inputs increase the noise output from the circuit. In low-gain circuits, however, the benfits may outweigh the noise problems.

frequency compensation problems

Ideal amplifiers of any type have an infinite bandwidth, so they will amplify all signals accurately and cleanly. Real amplifiers have frequency response limitations; for op-amps these limitations can be quite severe. There are two problems to consider with regard to frequency response: the bandwidth and stability of the system. The frequency response problem requires us to understand the gain bandwidth product of the amplifier.

The gain bandwidth product (GBP) is the product of the voltage gain and the maximum bandwidth of the device. GBP is specified as the frequency in MHz or kHz at which the gain of the op-amp drops to unity (i.e., 1). **Figure 10** plots the voltage gain against the frequency response of an amplifier. The gain remains relatively constant over a certain frequency range, but begins to fall above a certain point. At some frequency (1,000,000 Hz in this case), the gain drops to unity.

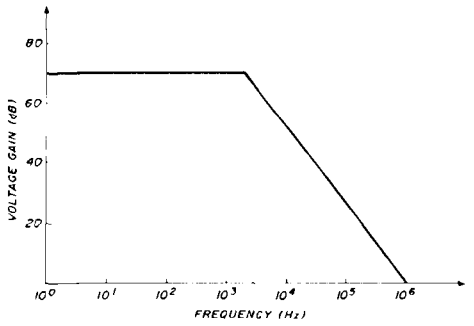


fig. 10. Gain-Bandwidth plot for a typical op-amp.

You'll run into GBP when you try to obtain high gain and wide frequency response in the same amplifier. A cassette tape preamplifier, a microphone preamplifier, and certain instrumentation amplifiers are examples where gain and wide bandwidth frequency response go hand in hand. These examples also illustrate the problems of GBP most distinctly. Suppose you need a voltage gain of 40 dB (a gain of 100) and a frequency response of 10 kHz (10,000 Hz). The gain bandwidth product required of the op-amp is:

$$GBP = A_v \times F \quad (9)$$

$$GBP = (100)\ (10{,}000\ Hz) \quad (10)$$

$$GBP = 1{,}000{,}000\ Hz = 1\ MHz \quad (11)$$

Stability is always an issue whenever op-amps are used. Almost invariably, when breadboarding a new circuit with wideband op-amps, the first attempt will result in an unwanted oscillation. One solution is to use a frequency compensated op-amp like the 741 (if the application permits). These devices are unconditionally stable — a condition that occurs at the expense of gain bandwidth product. Such an op-amp will work as an ac amplifier only to frequencies of a few kHz.

These difficulties can be created from any of several problems. Layout, for example, can create oscillation. If the stray capacitances and inductances create a resonant situation at a frequency lower than the unity gain frequency, then the circuit will oscillate. Similarly, if the dc power supply is not properly decoupled, problems can occur. This latter problem occurs especially in multistage circuits where one stage can affect the other. Be careful of disc ceramic capacitors — some of those components have very significant stray inductances and can form resonant circuits that do not bypass very well at one frequency. If that resonant frequency is below the GBP frequency, oscillation may occur.

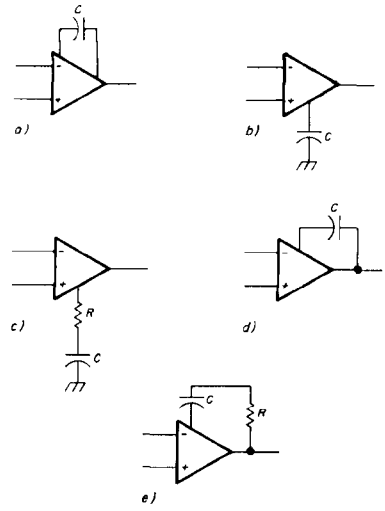


fig. 11. Frequency compensation capacitor circuits.

Grounding problems in the circuit can also create obstacles. One cause of oscillations here is an impedance in the ground circuit common to both input and output circuits. Because output signal flowing in that impedance is also in series with the input circuit, feedback automatically exists.

If any combination of feedback and phase shift occurs between output and input, at a frequency that is less than the unity gain GBP frequency, oscillation can occur. Several ploys are used to reduce the gain at frequencies less than GBP to prevent oscillation. Some of these methods are shown in **fig. 11**. Note the use of a capacitor (**fig. 11A**) across the frequency compensation terminals found on some op-amps. The manufacturer typically specifies a capacitance in the data sheet for the device. Values in the 30-to-100 pF range are common. Standard practice is to make this capacitance the value for the noninverting unity gain follower configuration. For all other configurations with gain, the value of the capacitance required is the noninverting unity gain value multiplied by the feedback factor, B:

BLACK DACRON® POLYESTER ANTENNA ROPE

- UV-PROTECTED
- HIGH ABRASION RESISTANCE
- REQUIRES NO EXPENSIVE POTTING HEADS
- EASY TO TIE & UNTIE KNOTS
- EASY TO CUT WITH OUR HOT KNIFE
- SIZES: 3/32" 3/16" 5/16"
- SATISFIED CUSTOMERS DECLARE EXCELLENCE THROUGHOUT U.S.A.

LET US INTRODUCE OUR DACRON® ROPE TO YOU • SEND YOUR NAME AND ADDRESS AND WE'LL SEND YOU FREE SAMPLES OF EACH SIZE AND COMPLETE ORDERING INFORMATION.
Dealer Inquiries Invited

synthetic textiles, inc.
2472 EASTMAN AVE., BUILDING 21
VENTURA, CALIFORNIA 93003
(805) 658-7903

164

NEW SUPER FAST C-64 LOGGING PROGRAM
from WA0LIB and Charlie Stone

A revolutionary new contest program for the C-64 computer designed and tested by active contesters. Can be used in CQWW, ARRL Sweeps, Field Day, ARRL DX Test or any other Contest. Can be used with ONE OR TWO DISKDRIVES. Superfast dupechecker with real time clock ON or OFF. 3,000 QSOs stored per band on your data disk. Special print and formatting routines plus much more. Easy-to-use and user friendly. Worth twice the price.

Just $39.95 plus $3.50 shipping and handling

Also available QSL CARD FILE DATA BASE.
Organize your QSLs on computer for fast and easy retrieval of information. Each file has 28 fields which can be filled in or edited at any time. Each data disk will accept 400 complete records. Includes special print routine.

Just $19.95 plus $3.50 shipping and handling.

BUY BOTH SPECIAL
Contest Logger @ $39.95 plus
QSL Data Base @ $19.95
Regular $59.90

SPECIAL SALE PRICE JUST $49.90
Save $10! plus $3.50 shipping & handling

We accept VISA/MASTERCARD-PERSONAL CHECKS.

RIEBSTONE SOFTWARE CO.
P.O. Box 13532
St. Louis, Missouri 63137

157

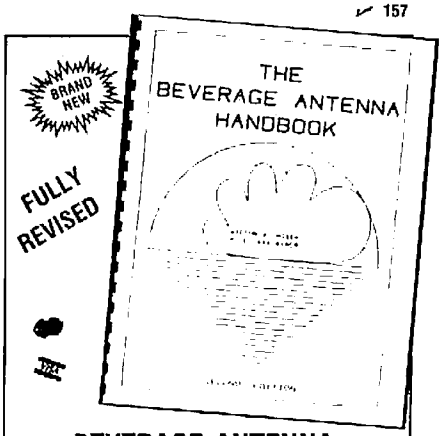


R-7000 Widespan Panadaptor

Panadaptor especially designed for the R-7000 receiver. For use with a standard scope. Variable span width from 1 to 10 Mhz. Uncover unknown elusive signals. Complete with all cables, & 90 day warranty. $349.95 Shipped. Pa. res. add 6%.

GTI Electronics
RD 1 BOX 272
Lehighton, Pa. 18235
717-386-4032

165



BEVERAGE ANTENNA HANDBOOK

by Vic Misek, W1WCR New Edition

W1WCR has spent countless hours developing new antenna ideas and optimizing the SWA (Steerable wave antenna.) Misek delves deep into the secrets of the single wire Beverage with helpful hints and tips on how to maximize performance based upon wire size, height above ground, overall length and impedance matching. Also includes information on center fed Beverages constructed out of several wire types. **SMALL LOT OWNERS** -- Beverage for you too! Called the Micro-SWA, it is just 60 ft long. You get excellent directivity and null steering capabilities. Transformer design information for both termination and feedline matching is completely revised. 1987 80 pages
VM-BAH Softbound $14.95

Please enclose $3.50 shipping & handling

ham radio BOOKSTORE
GREENVILLE, NH 03048 *603-878-1441*

HI-PERFORMANCE DIPOLES

WPD-5

ANTENNAS THAT WORK! CUSTOM ASSEMBLED TO YOUR CENTER FREQ. EX. BAND - ADVISED BY OF CENTER AND EACH END - HANG AS INVERTED "V" - HORIZONTAL, VERT DIPOLE, SLOPING DIPOLE - COMMERCIAL QUALITY - STAINLESS HARDWARE - LEGAL POWER 80-TRAP, HIGH-EFFICIENCY DESIGN. PERSONAL CHECK, MO, OR C.O.D. 1988

WPD-5* 80-40-20-15-10M MAX-PERFORMANCE DIPOLE 83' LONG.....$105ppd
WPD-7 80-40A MAX-PERFORMANCE DIPOLE, 65'-LONG 467,...95' 565ppd
WPD 8* 160-80-40M HI-PERFORMANCE DIPOLE 133' LONG.....$79ppd
SSD-8* 160-80-40-20-15-10M SPACE-SAVER DIPOLE 71' LONG.....$125ppd
SSD 5* 80-40-20-15-10M SPACE SAVER DIPOLE-SPECIFY L. 62'-$105, 52'-$100ppd
SSD-4* 80-40-20-15M SPACE-SAVER DIPOLE-SPECIFY L. 46' 8 VE. 40'-$ 95ppd
*W-BANDS WITH WIDE-MATCHING-RANGE TUNER.

DATA FOR CATALOGUE #9 10 DIPOLES, SLOPERS, & SPACE-SAVING, UNIQUE ANTENNAS

W9INN ANTENNAS 312-394-3414
BOX 393 MT. PROSPECT, IL 60056

166

$$C_{req} = C \times B \quad (12)$$

Where:
C_{req} is the required capacitance

C is the specified capacitance for noninverting unity gain

B is the feedback factor

Factor B is merely the transfer function of the feedback network. In the usual circuit with a resistor feedback network, the value of B is:

$$B = \frac{R1}{R1 + R2} \quad (13)$$

Where:
B is the feedback factor
R1 is the input resistor
R2 is the feedback resistor

For example, let's suppose that an inverting amplifier with a gain of 10 has a rated compensation capacitance of 30 pF for the unity gain configuration. Assume the feedback resistor (R2) is 100k, and the input resistor (R1) is 10k. The value of B is:

$$B = \frac{10k}{10k + 100k} \quad (14)$$

$$B = 10/110 = 0.091$$

The value of the capacitance required to stabilize this amplifier is:

$$Creq = C \times B \quad (15)$$

$$Creq = (30\ pF)\ (0.091) \quad (16)$$

$$Creq = 2.7\ pF \quad (17)$$

Figures 11B through **11E** show variations. The values of the components are taken from charts or graphs in the specifications sheet for the particular op-amp being used.

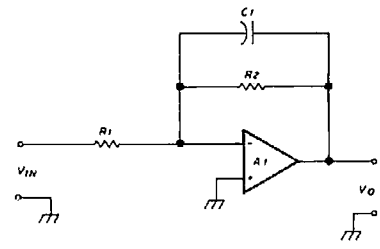


fig. 12. Feedback capacitor controls frequency response.

Input Capacitance Compensation. **Figure 12** shows the method for compensating for stray input capacitance. The circuit shown here is an inverting follower with a capacitance shunting the feedback resistor. From dc to a given frequency, F1, the gain of the amplifier is given by the equation:

$$A_V = -R2/R1 \qquad (18)$$

At frequency F1, the gain begins to drop off at a rate of −6 dB per octave. The breakpoint frequency (F1) at which this happens is:

$$F1 = \frac{1{,}000{,}000}{2\,\pi\,R2 \cdot C1} \qquad (19)$$

Where:
F1 is the frequency in Hz
R2 is in ohms
C1 is in microfarads

The input resistance and the input capacitance (which consists mostly of stray capacitances) form a phase shift at certain frequencies defined by $1/2\pi R1C$, where C is the stray input capacitance. If that frequency is below the unity gain frequency, then it is possible for the phase shift that occurs at this frequency to add to the op-amp's ordinary phase shift (180 degrees ± error for inverting followers) to form a 360-degree phase shift, which is the criterion for oscillation. To compensate for this stray capacitance, select a value of C1 (**fig. 12**) that has a capacitive reactance of approximately one-tenth the resistance of R2.

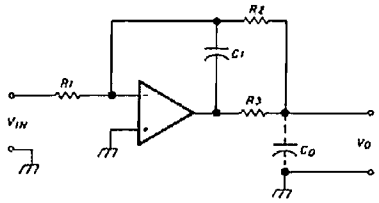


fig. 13. Alternate feedback capacitor circuit.

Figure 13 shows the method for compensating for high output load capacitances. This situation occurs, for example, when the op-amp drives a coaxial cable or twisted pair transmission line. Capacitor C1 is selected to have a capacitive reactance of one-tenth R2, while R3 is selected to have a value of several hundred ohms.

conclusion

The linear IC, especially the operational amplifier, is a powerful tool for communications circuit designers. Although the practical IC device doesn't measure up to the textbook version, it is useful because its problems are easily solved.

for further reading

Joseph J. Carr, *IC User's Casebook*, Howard W. Sams & Company, Inc., No. 22488, $12.95.

Joe Carr, K4IPV, can be contacted at POB 1099, Falls Church, Virginia 22041. He welcomes your questions, comments, and criticisms.

ham radio

QRZ Contest!™
VHF Contest Software
for PC Compatibles
$39.95 postage paid
→ Covers all VHF and UHF contests
→ Includes the 70 MHz European band
→ Menu driven and user friendly
→ Color and options user configured
→ Grids worked display on-line!
→ Full dupe checking
→ Complete log editor included
→ Handles 4000 contacts with 512K
→ Demo-version $5.00 (refundable with purchase of full program)
+ HF version to be available soon!
ATFAB Computers and Electronics
PO Box 4766, Maineville, OH 45039
(513)683-2042
VISA and Master Card Accepted

168

R-4C Enhancements
Custom AGC / Filter Switch Available
Custom AF / RF Knob Set Available
Plug-in Filters for Every Mode and Bandwidth
CF-1.7K/8, Sharp SSB. Better than FL-1500.
CF-1.0K/8, Wide CW. Super scanning filter
CF-500/8, Standard bandwidth CW.
CF-250/8, Narrow bandwidth CW.
Switchable First I-F Filter Solutions
CF-2K/8, Sharp filter pair for Contests and DX.
CF-5K/8, First I-F Replacement
CF-600/6, The Ultimate CW Upgrade
Sherwood Engineering Inc.
1268 South Ogden Street, Denver, CO 80210
(303) 722-2257 Monday - Friday 9 A.M. - 5 P.M.
Full Installation Dealers:
Design Electronics Ohio, KN8Z
(614) 836-5711 Days, (614) 836-3376 Evenings
LTA Industries, K3LR (412) 528-9302

A RACE ON THE EDGE OF TIME
Radar — The Decisive Weapon of WW II
by David E. Fisher
A Race On The Edge Of Time reads like a thriller but is based upon painstaking and comprehensive research by the author. In fact, Fisher argues rather convincingly that radar was the crucial factor that allowed the allies to win the war and that radar has played the same important role in our current military and political environment. Filled with fascinating twists and turns of history that could have changed the war's outcome, anecdotes about the personalities involved in the development of radar and other military insights. Also includes radar development post WW II and how it will influence future battles. Illustrated with rare vintage photographs and diagrams.
☐ MH-21088 **Hardbound $19.95**
Please enclose $3.50 shipping and handling
ham radio BOOKSTORE GREENVILLE, NH 03048 *603-878-1441*



Multiband QRV 160-10 Emergency Pack
Field Day Winner
Fastest Antenna in the West
The Emergency Pack contains QRV 160-10 All Band kink-proof weather sealed antenna, Quick Launch kit, 70' RG-8x feedline, 160 meter adapter, all band counterpoise, 200' rotproof line. Complete and QRV. One person installs in 15 minutes.
$139.95 +$10 P.&H. and 51 page Tech Manual
Infopack $1 by 1st class mail.
Dept 11, Provo, UT 84603-1144
AntennasWest (801) 373-8425

118

a simple low-cost comb generator frequency calibrator

Produces pulses for test equipment calibration

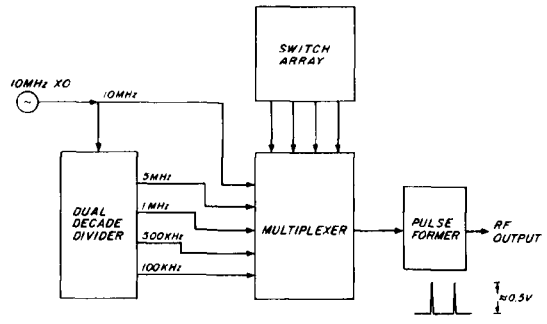


fig. 1.Block diagram of the comb generator. It is constructed on a 1.5 x 3.2-inch (3.8 by 8.1 cm) pc board.

Here's the construction and theory behind a simple digital comb generator* that produces accurate (crystal-controlled) pulses and can be used to calibrate a wide variety of test equipment. One possible application is the calibration of a spectrum analyzer (like the "Low-cost Spectrum Analyzer with Kilobuck Features," *ham radio*, September 1986, pages 82-90). It can also be used to align receivers, and to provide a stable comparison for calibrating various kinds of signal sources. A bandpass filter can be used to select any *tooth* of the comb to provide a single, pure signal.

A block diagram is shown in **fig. 1**. The heart of the generator is a crystal-controlled 10-MHz clock oscillator. Although a clock with moderate accuracy (±0.05 percent) is used in this model, more accurate oscillators are available in the same package style if you want higher stabilities. The oscillator's output is then divided down in frequency by a digital divider to a minimum frequency of 100 kHz. A multiplexer is used to select one of the signals from the divider chain or the 10-MHz signal. The multiplexer output drives the clock input of a high-speed CMOS D-type flip-flop, connected so that when a clock pulse is applied it tries to reset itself. This causes a narrow pulse about 6 nanoseconds wide to appear at its output. The repetition rate of this pulse train is the same as the applied input signal to the flip-flop, and when viewed in the frequency domain appears as a series of teeth separated in frequency by the repetition rate of the pulses. The schematic for the comb generator is shown in **fig. 2**; a parts list is provided.

The crystal oscillator, U3, can be purchased as a component in a DIP style package with a wide variety of specifications in terms of output levels and frequency accuracy. You'll need a part with either a CMOS or TTL compatible output for this application. The accuracy of the oscillator used in this comb generator is specified as ±0.05 percent (about ±72 kHz at 2 meters). Oscillator output is applied to both a frequency divider, U1, and one input of an eight-input multiplexer, U2. The frequency divider is a 74LS390 dual decade counter. It is hooked up so that its outputs furnish pulse repetition rates of 5, 1, 0.5, and 0.1 MHz simultaneously. All these outputs are then connected to the multiplexer inputs.

A quad DIP switch is used to select one of the five signals which appear at the output of the multiplexer, U2 (a 74LS151). DIP switch coding for the various output frequencies is shown in **table 1**. The multiplexer output is connected to the clock input of a high-speed CMOS D-type 74AC74 flip-flop, U4. The D input of the flip-flop is always wired high, so the flip-flop will set when the rising edge of a clock pulse occurs. The Q complement is wired to the flip-flop's reset pin; as

*It is called a comb generator because when its output is viewed in the frequency domain, as with a spectrum analyzer, the pattern resembles a comb.

By Larry Martin, PO Box 997, Sebastopol, California 95472

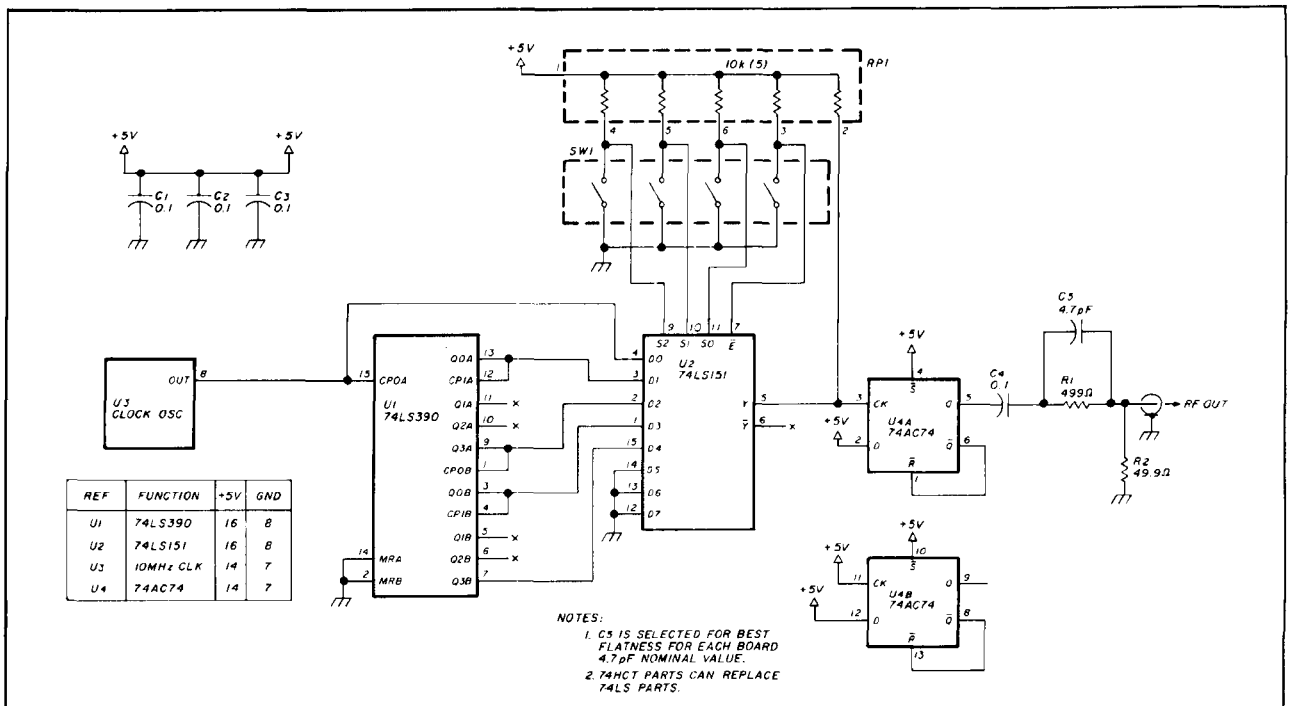


fig. 2. Detailed schematic of the comb generator. It uses four integrated circuits and a few other passive components.

Table 1. Output Frequency Coding

DIP Switch Code	Output Pulse Repetition Rate
0000	Output is disabled
0001	Output is disabled
0010	Output is disabled
0011	Output is disabled
0100	Output is disabled
0101	Output is disabled
0110	Output is disabled
0111	Output is disabled
1000	Output is disabled
1001	Output is disabled
1010	Output is disabled
1011	100-kHz rate
1100	500-kHz rate
1101	1-MHz rate
1110	5-MHz rate
1111	10-MHz rate

Ref. Desig.	Part Description	Mant'r	Qty.
C1	0.1 uF 50 V CK05 Capacitor	AVX	4
C2	0.1 uF 50 V CK05 Capacitor		—
C3	0.1 uF 50 V CK05 Capacitor		—
C4	0.1 uF 50 V CK05 Capacitor		—
C5	4.7 pF nominal value, CK05 Capacitor (Set at test)	AVX	1
J1	BNC PC Mount Jack	AMP	1
R1	499 ohm 1% 0.1 W resistor	Corning	1
R2	49.9 ohm 1% 0.1 W resistor	Corning	1
RP1	6 pin 5 resistor 10K ohm SIP	Bourns	1
SW1	4 position DIP switch	Grayhill	1
U1	74LS390N Dual Decade Counter	TI	1
U2	74LS151N Multiplexer	TI	1
U3	10 MHz Clock Oscillator	Dale	1
U4	74AC74PC Dual D Flip-flop	Fairchild	1
X1	Printed Circuit Board	LMCA	1

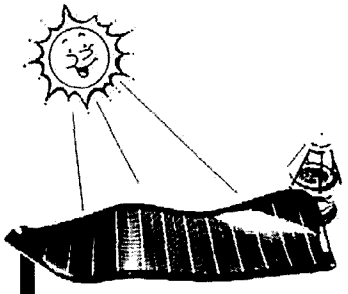
soon as the flip-flop is set (its output rises to 1), the complement output goes low, and the flip-flop is forced to reset. Its output is a narrow pulse whose width is limited only by the time delays through the internal logic of the flip-flop and the wiring delays associated with the pc board. This pulse, shown in **fig. 3**, is typically 6 nanoseconds wide.

This pulse train, when viewed in the frequency domain, looks like a comb (see footnote) as shown in **figs. 4** and **5** for a 10-MHz pulse repetition rate. **Figure 4** shows the output of the comb generator with a 10-MHz repetition rate from 0 to 100 MHz, while **fig. 5** shows the output spectrum of the same waveform from 0 to 1000 MHz. These figures show that the typical output is flat to within ± 1 dB from 0 to 100 MHz (careful adjustment of C5 can reduce the flatness to less than ± 0.6 dB) and that the comb generator is useful to above 1000 MHz.

The comb generator can be used as a very stable, pure tone generated by filtering one of the output teeth. The spectral purity of the 100-MHz tooth of the comb generator is seen in **fig. 6**, which shows the noise within a 1-kHz frequency span (with a 10-Hz resolution bandwidth). Note that the line-related sidebands are over 70 dB down.

Figures 7, 8, 9, and **10** show the output spectrum

LET THE SUN DO THE WORK



- Charge batteries on stored machinery
- Light your tent
- Run fans
- Run remote transmitters
- Light signs
- Pump water for your animals
- Power for your motor home
- Run your radio without batteries
- Light your home
- Yard lights
- Charge flashlight batteries
- Light your cabin
- Run electric fences
- Charge your boat battery
- Run appliances in your home
- Charge hand held radio batteries
- Fish shanty lights
- Charge your Camcorder battery pack

Electricity from the Sun with

SOVONICS™ Solar Systems

ALSO: *OUTSTANDING* PRICES ON IBM XT COMPATIBLE SYSTEMS!

SHIPPING INFORMATION: PLEASE INCLUDE 10% OF ORDER FOR SHIPPING AND HANDLING CHARGES (MINIMUM $2.50, MAXIMUM $10). CANADIAN ORDERS, ADD $7.50 IN US FUNDS. MICHIGAN RESIDENTS ADD 4% SALES TAX. FOR *FREE* FLYER, SEND 22¢ STAMP OR SASE.



HAL-TRONIX, INC.
12671 Dix-Toledo Hwy
P.O. Box 1101
Southgate, MI 48195

(313) 281-7773
Hours
12:00 - 6:00 EST Mon-Sat

"HAL" HAROLD C. NOWLAND
W8ZXH

169

CTM SALE CTM

Going-out-of-Business

CTM had too many readers and not enough subscribers to make a profit. Too many people copying CTM and passing it around to their friends month after month after month!

A sure way to kill a magazine!

In an effort to help those who had to have their subscription returned, we will sell back issues for only **$2.00 each plus $2.00 S&H each order** as long as they last. **U.S. ONLY! Canadians $3.00 ea. Other Countries $7.00 each.** Some issues in short supply. We were your best and largest source of **Packet Radio information.** We had 65 articles in 1987 and, 32 in 1988.

A SPECIAL THANKS to our fine writers who made CTM the GREAT magazine it was!

Send your Ck, M.O., (M/C, Visa +5%) to:
Chet Lambert, W4WDR
1704 Sam Drive
Birmingham, AL 35235
(205) 854-0271

196

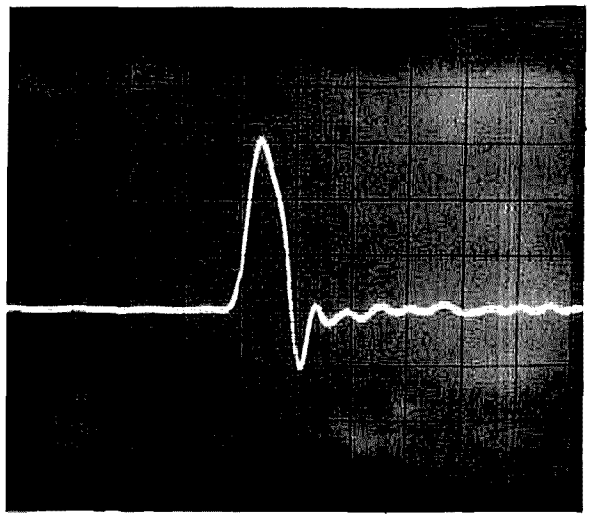


fig. 3. Output pulse of the comb generator. The horizontal scale is 10 nSec/div and the vertical scale is 0.2 V/div. The repetition rate of the pulses depends on the switch settings.

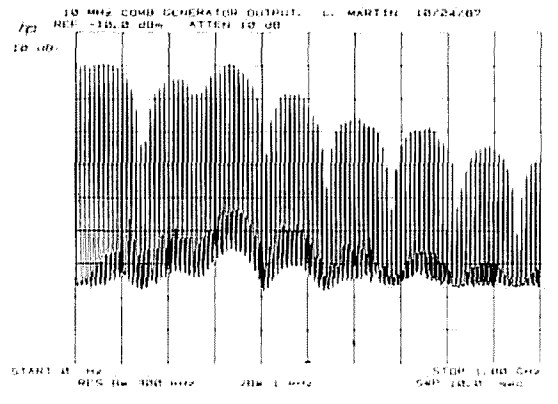


fig. 4. The output spectrum of the comb generator with a 10 MHz repetition rate. The vertical scale is 10 db/div and the horizontal scale is 10 MHz/div. The flatness of the generator is better than ± 1 dB.

for a 5-MHz repetition rate, a 1-MHz repetition rate, a 500-kHz repetition rate, and a 100-kHz repetition rate, respectively. Note that the amplitude of each tooth is reduced by the ratio of the repetition rates. This is because the energy in each pulse is spread into many more comb teeth, reducing the amplitude of each tooth when the repetition rate is reduced. **Figure 11** shows the output of the 100-kHz repetition rate signal over the 20 to 30-MHz frequency range and gives an indication of the flatness of the comb generator in the hf frequency bands.

The comb generator is constructed on a double-sided pc board with plated through holes. All compo-

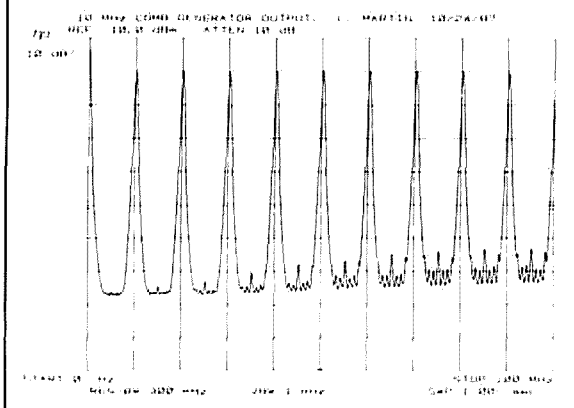


fig. 5. A broadband view of the comb generator output. The vertical scale is 10 dB/div and the horizontal scale is 100 MHz/div. This shows that the comb generator has useful outputs up into the low microwave range.

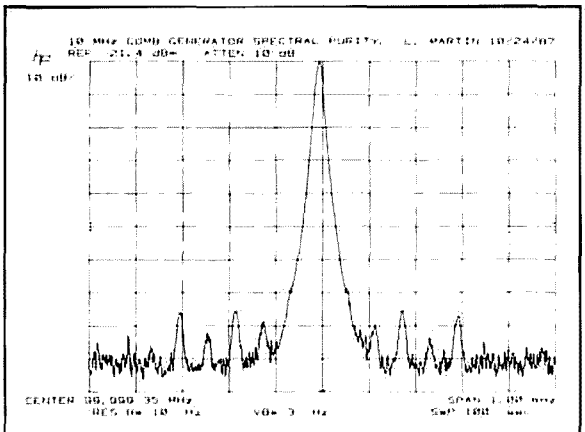


fig. 6. The close in spectral purity of the 100-MHz tooth of the comb generator when set to a 10 MHz-repetition rate. The horizontal scale is 100 Hz/div and the vertical is 10 dB/div. The spurious sidebands are multiples of 60 Hz.

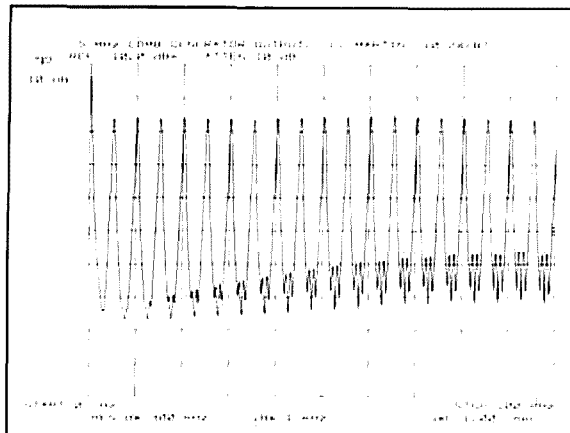


fig. 7. The output of the comb generator with a 5-MHz repetition rate. The horizontal scale is 10 MHz/div and the vertical scale is 10 dB/div.

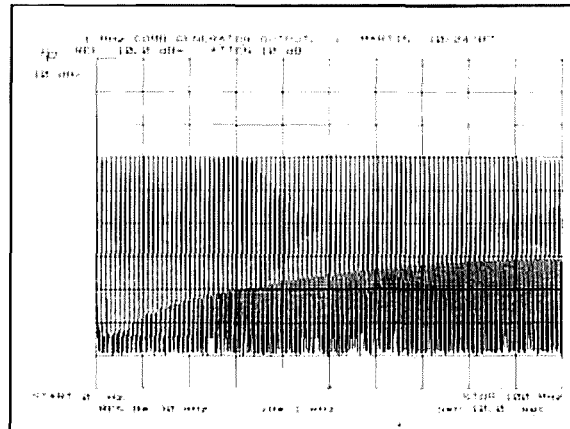


fig. 8. The output of the comb generator with a 1-MHz repetition rate. The horizontal scale is 10 MHz/div and the vertical is 10 dB/div. Note that the amplitudes of each of the teeth has decreased as their quantity has increased.

nents are soldered to the board without sockets to minimize component lead lengths and reduce any switching spikes which could upset the output pulse waveshape. The generator uses 65 mA from a + 5 volt supply.

A major use of the comb generator is calibration of test equipment — for example, a typical spectrum analyzer. The tunable oscillator in most rf spectrum analyzers is a varactor-tuned oscillator. This oscillator has an inherently nonlinear tuning curve, so when an unknown signal is measured, the analyzer must be calibrated to determine its frequency. The comb generator allows this calibration to be done efficiently.

First connect the unknown signal to the spectrum analyzer, set the analyzer to a wide frequency span (0 to 100 MHz), and note the position of the signal on the screen. Disconnect the signal and connect the comb generator to the spectrum analyzer. Set the comb repetition rate of the generator to 10 MHz, and count the number of comb teeth to the unknown signal to the nearest 10 MHz. Next, set the comb generator to 5 MHz and repeat the process; this sets the frequency of the unknown signal to 5 MHz. Then retune the analyzer so the unknown signal is on the screen and bracketed by two visible comb teeth (whose exact frequencies are known). Reconnect the unknown signal to the spectrum analyzer and note its new position. Repeat the above procedure, with

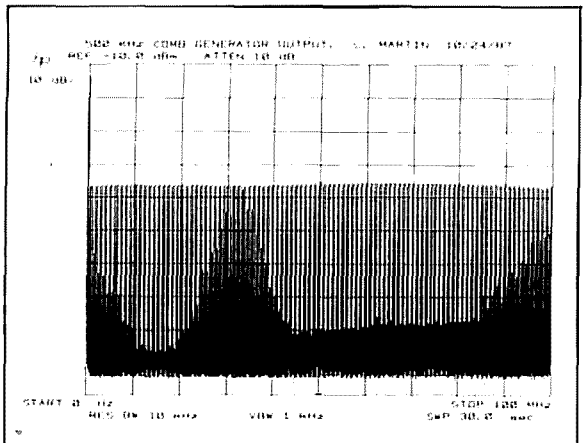


fig. 9. The output of the comb generator when set to a 500-kHz repetition rate. The vertical scale is 10 dB/div and the horizontal is 10 MHz/div.

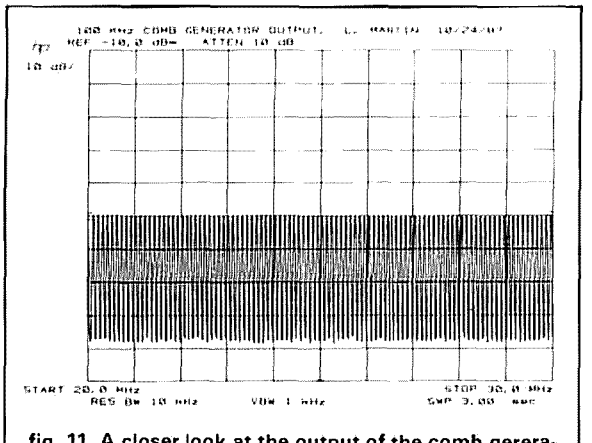


fig. 11. A closer look at the output of the comb gererator with a 100-kHz repetition rate. The vertical scale is 10 dB/div and the horizontal scale is 1 MHz/div centered at 25 MHz.

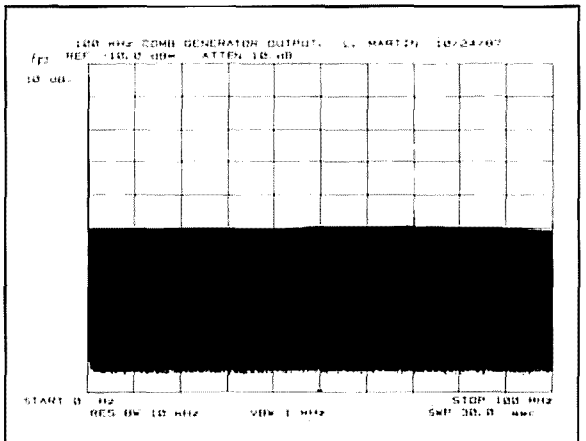


fig. 10. The output of the comb generator with a 100-kHz repetition rate. The vertical scale is 10 dB/div and the horizontal is 10 MHz/div.

smaller and smaller steps between the comb teeth, until the frequency of the unknown signal is estimated by interpolation between the nearest two 100-kHz comb teeth. You will be able to determine the frequency of the unknown signal to about 1 or 2 kHz resolution because most oscillators are relatively linear over very small tuning ranges. The absolute accuracy of the crystal oscillator sets the absolute accuracy to which the unknown frequency can be measured. The above accuracy specification means that a 100-MHz comb tooth will have an accuracy of 50 kHz — much poorer than the measurement capability of the newly calibrated spectrum analyzer.

Many low-cost receivers are not frequency synthesized. The comb generator can also be used to calibrate receiver dials in steps as fine as 100 kHz with an iterative procedure similar to that used for spectrum analyzer calibration.

ham radio

CADDELL COIL CORP.

35 Main Street
Poultney, VT 05764
802-287-4055

BALUNS

Get POWER to your antenna! Our Baluns are already wound and ready for installation in your transmatch or you may enclose them in a weatherproof box and connect them directly at the antenna. They are designed for 3-30 MHz operation. (See ARRL Handbook pages 19-9 or 6-20 for construction details.)

100 Watt (4:1, 6:1, 9:1, or 1:1 impedence—select one)	$10.50
Universal Transmatch 1 KW (4:1 impedence)	14.50
Universal Transmatch 2 KW (4:1 impedence)	17.00
Universal Transmatch 1 KW (6:1, 9:1, or 1:1—select one)	16.00
Universal Transmatch 2 KW (6:1, 9:1, or 1:1—select one)	18.50

Please send large SASE for info

ALL BAND DIPOLE TRAP ANTENNAS!

PRETUNED-ASSEMBLED ONLY ONE NEAT SMALL ANTENNA FOR ALL BANDS! EXCELLENT FOR APARTMENTS! IMPROVED DESIGN!

FOR ALL MAKES AMATEUR TRANSCEIVERS! GUARANTEED FOR 2000 WATTS SSB INPUT FOR NOVICE AND ALL CLASS AMATEURS! CW-AM-FM

COMPLETE with 90 ft. RG58U-52 ohm feedline, and PL259 connector, insulators, 30 ft. 300 lb. test dacron end supports, center connector with built in lightning arrester and static discharge, sealed, weatherproof, traps. 1"X5" wt 3 oz. Low SWR over all bands -Tuners usually NOT NEEDED! Can be used as inverted V's - slopers - in attics, on building tops or narrow lots. WORKS ON NEW WARC BANDS! The ONLY ANTENNA YOU WILL EVER NEED FOR ALL BANDS! NO BALUNS NEEDED!

160-80-40-20-15-10 -- 4 trap - 169 ft. No. 1060E . $134.95
80-40-20-15-10 - - 2 trap - 104 ft. - No.- 998E . . . $99.95
40-20-15-10 -- 2 trap -- 54 ft. - No.- 1001E $98.95
20-15-10 meter - 2 trap - 26ft. - No.- 1007E $97.95

SEND FULL PRICE FOR PP DEL. IN USA. (Canada is $5.00 extra for postage etc) order using VISA - MASTER CARD - AMER. EXPRESS. - Ph 1-308-236-5333 week days. We ship in 2-3 days. (Per C.K.'s 14 days) All antennas guaranteed for 1 year. 10 day money back trial if returned in new condition! Made in USA. FREE INFO. AVAILABLE ONLY FROM

WESTERN ELECTRONICS
Dept. AH Kearney, Nebraska, 68847

AMATEUR RADIO MAIL LISTS
Self-stick 1x3 labels

*** NEWLY LICENCED HAMS ***
*** ALL NEW UPGRADES ***
*** UPDATED EACH WEEK ***

Total List = 462,728 (ZIP sorted)
Price is 2.5 cents each (4-up Cheshire)

BUCKMASTER PUBLISHING
Mineral, Virginia 23117
703-894-5777
800-282-5628

171

170



DX FORECASTER

Gerth Stonehocker, KØRYW

summer thunderstorm noise

At any given moment an estimated 3600 thounderstorms are in progress around the world. They can be classified as air mass, frontal, or orographic, depending on how they're formed. The main source of summertime QRN is the air mass thunderstorm, which builds up from the sun heating the ground and the air above it.

The process works as follows. The sun heats the ground; as the heat from the ground rises, it warms the air above and causes it to rise. As this heated air meets the colder air above, its moisture condenses, forming clouds. The clouds — some of which may be seized by the winds and carried into the jet stream to form the characteristic anvil-shaped top of a thunderhead at 30 to 40,000 feet — continue to rise until their condensed moisture forms drops heavy enough to fall as rain. Some drops are taken further upward and freeze into hail. This fast up-and-down motion generates static electricity strong enough to cause the air to break down between a cloud and the earth or between one cloud and another. As the lightning stroke releases this energy it produces sound and electromagnetic pulses. Our receivers pick up the hf radio frequency pulse we call "noise." Most air mass storms form on afternoons when the humidity is above 50 percent, and last into the night before cooling off enough to dissipate. Air mass thunderstorms linger for several days until rain releases their moisture or they slowly move on.

During the evening DXing hours, air mass thunderstorm QRN may limit the usefulness of low-band signals to local ragchewing, and for the most part, rule out weak-signal DX. The QRN, propagated from the equatorial land regions, or closer, increases the overall average noise level on the 80- and 160-meter bands. This is because the tropical areas get closer to those of us in the Northern Hemisphere in the summer as the sun comes up to 23°N. A hop or two is cut off from the propagation distance adding a few dB to the noise. Several areas which develop many air mass thunderstorms are even closer — Florida and the eastern side of the Rocky Mountains in Colorado and Nebraska, followed by the southeastern part of the United States are the top producers.

How can you communicate with DX stations on these bands? Directional antennas may help if the thunderstorm activity is in the opposite direction from the DX stations. If you can avoid pointing your beam at these areas, you can help minimize noise pickup. In fact, if you can get the back of the antenna pointed in that direction, you can use the front-to-back ratio (typically 15 dB) to further decrease noise pickup. This may mean working a DX country over the long path or over the Pole. If the ionosphere will support propagation in that direction and no geomagnetic field disturbance is occurring, you may find this the solution to some of the summer noise problems.

last-minute forecast

Expect DX conditions for the higher frequency bands to be best during the middle of the month because of increased solar flux with its higher MUFs. Transequatorial one-long-hop skip is nil this month but sporadic E short skip and regular long skip should fill in well. The lower frequency signal strengths decrease during daylight hours when the flux is high, and because of noise this month, conditions really suffer. Nighttime signals will be best the first and last weeks of the month. Look for sunrise and sunset enhancement from sporadic E short skip to help signals get through the noise. Try those early morning operating hours.

band-by-band summary

Six-meter sporadic E short-skip conditions on some days will last anywhere from 30 minutes to a couple of hours around local noon. Expect about 1000 miles per hop.

Ten, 12, and 15 meters will have quite a few short-skip E_s openings and some long-skip openings during the 27-day solar flux peaks to southern areas of the world during daylight hours. Fifteen meters will be best for only an hour or two as the maximum usable frequency decreases during the late afternoon.

Twenty, 30, and 40 meters will be

WESTERN USA

GMT	PDT	N	NE	E	SE	S	SW	W	NW
0000	5:00	20	20	20	12	15	10	10	15
0100	6:00	15	30	20	12	15	10	10	15
0200	7:00	15	*30*	*20*	15	20	10	10	12
0300	8:00	15	*30*	*20*	15	20	10	10	12
0400	9:00	15	*30*	*20*	20	20	10	10	15
0500	10:00	20	20	20	20	30	12	12	15
0600	11:00	20	20	15	20	30	12	12	15
0700	12:00	20	20	15	20	30	12	15	20
0800	1:00	20	*30*	15	20	30	15	20	20
0900	2:00	*20*	*30**	20	*20*	30	15	20	20
1000	3:00	*30*	20	20	*20*	*30*	20	20	20
1100	4:00	*30*	20	20	*30*	*30*	20	20	20
1200	5:00	20	20	15	20	*30*	*20*	20	*30*
1300	6:00	20	20	12	20	*30*	*20*	*20*	*30*
1400	7:00	20	20	12	15	*30*	*20*	*20*	20
1500	8:00	20	15	10	12	*30*	*20*	*20*	20
1600	9:00	20	15	10	12	*30*	*20*	*20*	*30*
1700	10:00	20	15	10	12	20	20	*30*	*30*
1800	11:00	20	12	*12**	10	20	15	*30*	20
1900	12:00	*30*	15	12	10	20	12	20	20
2000	1:00	*30*	15	15	10	15	12	12	20
2100	2:00	20	20	15	10	15	12	12	20
2200	3:00	20	20	20	10	15	10	10	20
2300	4:00	20	20	20	10	15	10	10	15

MID USA

MDT	N	NE	E	SE	S	SW	W	NW	CDT
6:00	20	20	20	12	20*	10	10	15	7:00
7:00	20	30	20	12	20	10	10	15	8:00
8:00	15	*30*	*20*	15	20	10	10	12	9:00
9:00	15	*30*	*20*	15	20	10	10	15	10:00
10:00	20	*30*	*20*	20	30	12	10	15	11:00
11:00	20	20	20	20	30	12	12	15	12:00
12:00	20	20	20	20	30	15	12	20	1:00
1:00	20	*30*	20	20	30	15	15	20	2:00
2:00	*20*	*30*	20	*20*	30	20	20	20	3:00
3:00	*30*	20	*20*	*20*	30	20	20	20	4:00
4:00	*30*	20	20	*30*	*30*	20	20	*30*	5:00
5:00	20	20	15	20	*30*	20	20	*30*	6:00
6:00	20	20	15	20	*30*	*20*	20	20	7:00
7:00	20	20	12	15	*30*	*20*	*20*	20	8:00
8:00	20*	15	12	12	*30*	*20*	*20*	20	9:00
9:00	20*	15	10	12	*30*	*20*	*20*	*20*	10:00
10:00	20	15	10	12	*30*	*20*	30	*30*	11:00
11:00	20	15	10	10	20	20	*30*	*20*	12:00
12:00	20	15	10	10	20	15	*30*	20	1:00
1:00	20	20	12	10	20	12	15	20	2:00
2:00	*30*	20	12	10	20*	12	12	20	3:00
3:00	*30*	20	15	10	15	12	12	20	4:00
4:00	20	20	20	10	15	10	10	15	5:00
5:00	20	20	20	10	15	10	10	15	6:00

EASTERN USA

EDT	N	NE	E	SE	S	SW	W	NW
8:00	20	20	20	12	20	10	10	15
9:00	20	20	20	12	20	10	10	15
10:00	20	*30*	*20*	15	20	10	10	15
11:00	20	*30*	*20*	15	30	10	10	20
12:00	20	30	*20*	20	30	12	12	20
1:00	*20*	*30**	20	20	30	12	12	20
2:00	*30*	*30*	20	20	30	15	15	20
3:00	*30*	30	20	*20*	30	15	15	*20*
4:00	20	20	*20*	*20*	30	20	20	*30*
5:00	20	20	20	*30*	30	20	20	20
6:00	20	20	15	20	*30*	20	*30*	20
7:00	20	20	15	20	*30*	*20*	20	20
8:00	20	20	12	15	*30*	*20*	20	20
9:00	20*	20	12	12	*30*	*20*	20	20
10:00	15	15	10	12	*30*	*20*	*20*	20
11:00	20*	15	10	12	*30*	*20*	*30*	*20*
12:00	20	15	10	12	*30*	*20*	*30*	*30*
1:00	20	15	10	10	20	15	*30*	*20*
2:00	20	15	12	10	20	15	*30*	20
3:00	20	20	12	10	20	12	15	20
4:00	*30*	20	15	10	20	12	12	20
5:00	*30*	20	15	10	20	12*	10	20
6:00	20	20	20	10	20	10	10	15
7:00	20	20	20	10	20	10	10	15

JULY	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
WESTERN USA								
MID USA								
EASTERN USA				CARIBBEAN S. AMERICA				

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.
*Look at next higher band for possible openings.

RELY ON JAN FOR 3-WAY HELP:

1. TECHNICALLY CORRECT CRYSTALS TO YOUR SPECS.
2. QUICK TURNAROUND WITH HUGE INVENTORY, PROMPT SERVICE, AND OUR EMERGENCY ORDER PLAN.
3. LOW PRICES.

✓ 173

QUARTZ CRYSTALS FOR
TWO-WAY — INDUSTRY
MARINE — AMATEURS
SCANNERS — CBs
MICROPROCESSORS

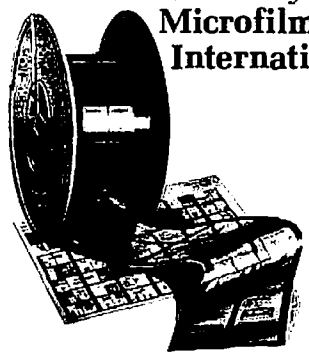
JAN CRYSTALS
SINCE 1965

FOR FREE CATALOG, CALL OR WRITE:
JAN CRYSTALS
P.O. BOX 06017
FORT MYERS, FL 33906
(813) 936-2397

VISA MasterCard

TOLL-FREE: 1-800-237-3063
IN FLORIDA: 1-800-226-XTAL
FAX ORDERS: 1-813-936-3750

This publication is available in microform from University Microfilms International.



☐ Please send information about these titles:

Name _____
Company/Institution _____
Address _____
City _____
State _____ Zip _____
Phone ( ) _____

Call toll-free 800-521-3044. In Michigan, Alaska and Hawaii call collect 313-761-4700. Or mail inquiry to: University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106.

useful for DX communications to most eastern, western, and northern areas of the world during daylight hours and into the evening most days, via long skip to 2000 miles per hop or by means of short-skip E_s, with 1000-mile hops. The period of daylight is still relatively long, but will be noticeably shorter by the end of the month.

Thirty, 40, 80, and 160 meters are all good for nighttime DX, even though the background noise is severe in the evenings. The direction of the openings will rotate from the east to the south and then westward in the morning. If you want to avoid thunderstorm QRN, sporadic E propagation may be helpful in the early evening toward the east and south. Try the early morning hours for communication paths to the west and monitor WWV or WWVH on 2.5 and 5 MHz as beacons.

ham radio

NUTS & VOLTS MAGAZINE

P.O. Box 1111-H
PLACENTIA, CA 92670
714-632-7721

Ham Radio
Computer Hardware
Computer Software
Plans-Kits
Schematics
Test Equipment
CB Gear
Satellite TV
Video
Components
Antique Electronics
Cable TV
Publications
Repairs-Services
New Products
Events Calendar

IF YOU ARE INTO ELECTRONICS AND SAVING MONEY IS IMPORTANT TO YOU, THEN YOU OWE IT TO YOURSELF TO TRY NUTS & VOLTS MAGAZINE. DISCOVER WHY THOUSANDS OF SMART PEOPLE NATIONWIDE TURN TO NUTS & VOLTS EACH MONTH TO MEET THEIR ELECTRONIC NEEDS. WHETHER YOU'RE BUYING, SELLING, OR JUST TRYING TO LOCATE THOSE UNIQUE OR HARD-TO-FIND ITEMS, FIND OUT HOW NUTS & VOLTS CAN HELP!

SUBSCRIBE TODAY!

☐ CHECK ☐ MONEY ORDER ☐ VISA ☐ MC

Name _____
Address _____
City _____
State _____ Zip _____
Card No. _____ Exp. Date _____

CALL FOR ADVERTISING INFORMATION
DISTRIBUTOR INQUIRIES INVITED

Subscription Rates
U.S. FUNDS REQUIRED

3rd Class Mail - USA
One Year $12.00
Two Years $21.00
Lifetime $60.00

1st Class Mail
One Year - USA . . . $20.00
Canada & Mexico . . $22.00

Air Mail
Foreign - 1 Year . . . $55.00

Includes one FREE 40-word Classified Ad

A National Publication For The Buying And Selling Of Electronic Equipment

✓ 174



ELMER's NOTEBOOK

Tom McMullen, W1SL

ten-meter skyware

The next upswing in the sunspot cycle is beginning, and the DX I've been hearing on the band lately indicates some interesting years ahead. It's time to get some equipment together, practice some operating techniques, learn to predict conditions, and use the band to garner a wall full of cards and awards.

Ten is a fun band. When it's open, big power and huge antennas don't count as much as operating technique and "being at the right place at the right time!" A few watts can pin an S-meter on the other side of the world, and there can be so many signals that you don't know which one to go after. At times you'll need a high frustration threshold; you'll hear plenty of loud signals that you can't work, but someone who is only an S7 or S8 will give you a "rock solid" QSO.

When the band decides to quit, the biggest beam and the highest power won't lengthen the QSO more than a few moments. That's what makes it so interesting for Novice operators. A 200-watt station and a modest antenna will often have a big signal; a few minutes spent analyzing the locations you're hearing and the paths that signals are using will tip you off as to what's going on.

antenna choices

As in many other parts of the spectrum, you have several antenna choices for 10 meters: verticals, dipoles, wire arrays, and beams. A vertical antenna, like a 1/4-wave groundplane, is a great all-around antenna for 10, and when conditions are good, makes a good showing. It's also useful for local ragchews when the band is not open; its nondirectional pattern lets you hear everyone within range without adjustment. When the band is open, a 1/4 or 1/2-wave antenna's lack of gain won't be any great hindrance, but your range will be limited for local work.

A dipole performs in much the same way; it does well on an open band, but shows a pronounced directional pattern. If you can rotate the dipole, you can use the directional characteristic to decrease the strength of unwanted signals and still pick up the wanted DX. For local work, rotate a dipole to favor stations you want. Again, lack of gain will limit the range on local contacts.

Wire arrays are not common on higher bands like 10 meters. Because this is a cross-over region, it is just as easy to make a rotary beam antenna like a Yagi as to rig supports for multi-element wire arrays. A relatively small lot can support a respectable amount of gain from arrays of phased dipoles, loops, etc., but you'll be gambling that the band will open in the direction that the array favors with its radiation pattern.

Ten-meter enthusiasts often choose Yagi antennas; it is surprisingly easy to put together a few pieces of tubing on an inexpensive rotator and push-up mast. Even a modest tripod on a roof will support a small beam. Let's look at a few basics of Yagi antennas and a couple of easy-to-construct examples.

The Yagi antenna was named for its developers — a couple of Japanese scholars named Yagi and Uda. It used to be called a "Yagi-Uda" array, but most people simply call it a "Yagi."

The Yagi array works on the principle that a piece of metal in the strong field of a nearby radiator will re-radiate a considerable amount of the energy it intercepts, and that this energy will differ in phase from that given off by the main radiating element. **Figure 1** shows this action in a two-element array. The main radiating element is the one that is fed energy from the transmitter and feedline. It is referred to as the driven element (DE). The second element intercepts the field radiated by the driven element. If the second ele-

ment is somewhat longer than the driven element, it is called a "reflector" (more on this later); if it is slightly shorter, it is called a "director." A simple two-element beam can be made with a driven element and *either* a reflector or a director; the difference in performance between the two types is minor. For slightly better performance, you can build a three-element Yagi using *both* a reflector and director.

In designing directional antennas of any type, the key to performance is the proper phasing of waves that interact with each other. Two sine waves exactly in phase will reinforce each other for a net gain; two that are exactly out of phase (180 degrees out) will cancel each other. The secret of directional antenna construction is to vary the spacing between elements and their length to get the correct phase for the desired result.

ing a weak-signal area ("null") off the back of the beam.

Some of the field is radiated up (where it's of no use) and some goes back toward the driven element. After this field passes the driven element it begins to do some good. If the reflector is spaced just right and is just the right length, the field it radiates forward will be "in phase" with the one from the driven element reinforcing it and providing gain in that direction. The name "reflector" comes from the element's apparent mirror reflection of the energy.

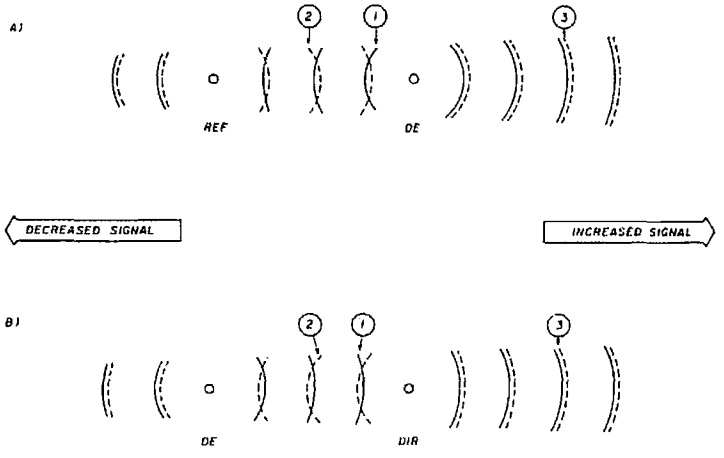


fig. 1. Yagi antennas work by radiated fields canceling or reinforcing each other. In A, the field (1) from the driven element (DE) is canceled to the rear by the field (2) from the reflector. The fields combine to provide a stronger signal (3) toward the front. The same action takes place in (B) where a director is used. The field from the director (2) cancels the driven-element's field (1) to the rear, and combines for a stronger field to the front (3).

In **fig. 1A**, the second element (a reflector) has had energy induced in it by the field from the driven element and re-radiates that energy as a field of its own (the dotted pattern). Some of this field continues to the back of the array, where it partially cancels the field from the driven element, producing a weak-signal area ("null") off the back of the beam.

A director re-radiates the energy in a way that reinforces the field from the driven element after that field has passed the director (see **fig. 1B**). This achieves the desired result of providing gain at the "front" of the beam, but doesn't produce as deep a null at the back. The director element is slightly shorter than the driven element. This length, along with the spacing from the driven element, provides the correct phasing so that the waveforms reinforce rather than cancel each other.

what's critical

The dimensions of the reflector and

5-1000 MHZ PREAMPLIFIERS

	NF	G	P(1dB)	$
WLA21m	3dB	13dB	8dBm	54
WLA22m	4	11	12	58
WLA23m	4	23	12	83
WLA24m	3	20	18	109

430/50MHZ CONVERTER

RCX431 .15μV 20dB 99



WILAM TECHNOLOGY, Div. of
WI-COMM ELECTRONICS INC.
P.O. Box 5174, MASSENA, N.Y. 13662
(315) 769-8334

181

Crystal Filters
For most Ham Rigs from:
KENWOOD • YAESU • HEATHKIT
Also Drake R-4C/7 Line, COLLINS 75S3-B/C and ICOM FL44A, FL52A, FL53A clones.
Finest 8-pole Construction
ALL POPULAR TYPES IN STOCK
CW • SSB • AM
Ask about our 250 Hz CW filter special for Heath HW-9 QRP rig.
Phone for Information or to Order.
VISA/MC or COD accepted
Why risk disappointment? Buy time-tested Fox-Tango Filters to be sure!
FOX-TANGO Corp.
Box 15944, W. Palm Bch, FL 33416
Telephone (305) 683-9587

COUNTER DIALS



100-turn counter with crank, 0.1 to 99.9 indicated. 3x3 front plate; shaft 2¼"L x ¼" dia with coupler. 3 lbs sh. **#CR-100T-339**, used.....**$19.95**
#KN-100T-339, as above but with knob **$16.95**

CERAMIC ROLLER INDUCTOR, 14.3 uH; 24 turns #12 tinned-copper wire in 3.3"Lx2" dia coil. Shaft ⅜"Lx¼" dia. O/a 3x5x6, 4 lbs sh. **#339-L44-MED.** used.....**$28 $24**



Prices F.O.B. Lima, O. • VISA, MASTERCARD Accepted.
Allow for Shipping • Write for 1988 Catalog
Address Dept. HR • Phone 419/227-6573
FAIR RADIO SALES
1016 E. EUREKA • Box 1105 • LIMA, OHIO • 45802

182

director, and their spacing from the driven element are crucial to a Yagi's performance. The lengths are most critical. If they are too short or too long, they won't work, or will produce a beam pattern that has more holes than gain. The spacing between elements is not as critical as is their length — a reflector can be moved several inches (or a considerable fraction of a wavelength) before performance begins to fall off. However, the spacing between elements does have a great effect on the impedance of the driven element. It's possible to vary the spacing and element length to obtain a very deep null at the back of the antenna, but these are not the same dimensions that produce the maximum gain at the front. Most designs are a compromise that favors maximum gain, acceptable front-to-back ratio, and a driven element impedance that you can live with.

Table 1 shows dimensions you can use to put together two- or three-element beams and the approximate gain you can expect. The spacing between elements is not too critical; it can vary a couple of inches either way to take advantage of boom length. The element lengths shown should work very well, but are probably not optimum because the diameter-to-length ratio of the tubing used has some effect on the resonant frequency. If the antenna has a persistent high VSWR at your operating frequency, try changing the driven element length an inch or so. A wide range of impedance matching can be handled by the gamma match described later.

Table 1. Element dimensions and spacing for two- and three-element beams. Two two-element types are shown along with two sizes of three-element beams.

Reflector Length (Feet)	Spacing (Feet)	Driven Element Length (Feet)	Spacing (Feet)	Director Length (Feet)	Approximate Gain (dBd)*
17.6	5.21	16.8	—	—	4.5
—	—	16.8	3.47	16.1	4.5
17.6	3.47	16.8	5.21	16.1	7.8
17.6	6.95	16.4	6.95	15.7	8.5

*dBd = gain referenced to 1/2-wave dipole.

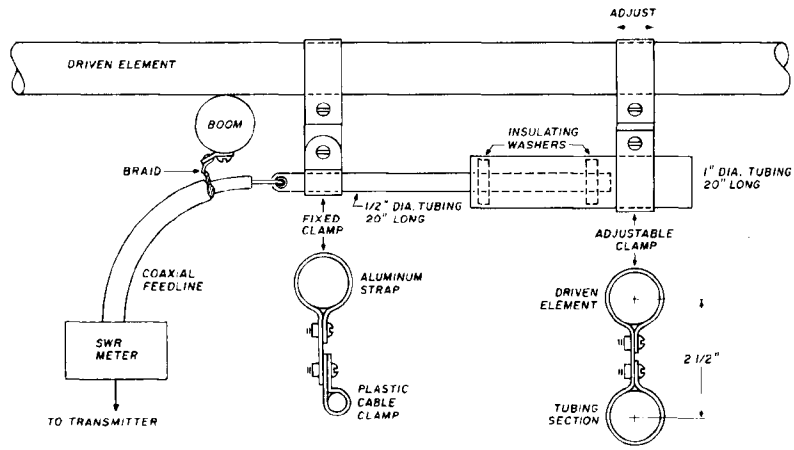


fig. 2. Gamma match will match coaxial-cable impedance (50 or 75-ohms) to the driven element of a Yagi antenna. The fixed clamp is not moved. The adjustable clamp is moved along the driven element, and the tubing section is moved within the clamp to provide lowest VSWR. Plastic or Teflon® washers inside the larger tubing keep the smaller tubing centered. The coaxial cable braid can be fastened to the boom with a sheet-metal screw, or a coaxial fitting and bracket can be placed there to make a more "professional" installation.

getting it all together

There are numerous advertisements in *ham radio* for antennas that come ready to assemble and put up, and you can hardly go wrong by this route. Some are single-band antennas, and many are versatile multiband systems that allow you to switch to a lower band when the highest frequency one folds up for the day.

If you're an incurable experimenter, it's easy to grab a few pieces of aluminum, some screws and bolts, and put together a simple signal snagger that satisfies the urge to try something new. Many hardware stores and do-it-yourself centers have aluminum angle stock and tubing that can be pieced together to make a respectable two- or three-element beam for 10 meters. Pieces of angle stock placed back-to-back form a "T" section boom that make it a cinch to fasten elements. Pieces of tubing that telescope into each other make excellent elements. Use a hacksaw to make slits in the ends of the larger pieces, slide the smaller ones inside a short distance, and use a stainless hose clamp to squeeze the larger one to grip the smaller. Sliding the outer sections in and out (especially on the driven element) allows some adjustment for proper VSWR. Don't worry about insulating the elements from the boom — it's not necessary.

You can often pick up damaged antennas of various types for next to nothing and salvage the parts to build your beam. Although damaged TV antenna elements are not large enough for 10-meter or lower bands, element-mounting hardware, boom material, and brackets to fasten the boom to the rotator mast are worth harboring for future need.

Another source of good parts is cast-off or surplus antennas for the 27-MHz Citizen's Band. Simply shorten the elements to the correct length and they'll work fine on 28 MHz. A word of advice — don't go for the fancy types with strange shapes or gadgets hanging from the elements; they add nothing but wind resistance. Fol-



Your SINGLE SOURCE for **MOBILE ANTENNAS!**

NEW...2 meter squared SSB mobile **$50.00**

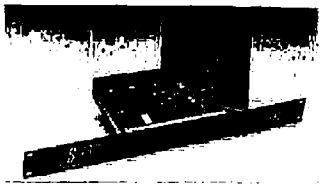
Bug Catchers...still the best HF mobile antenna 250 watt & 1kw sizes 80-10meters (we pay shipping on above items)

Call for other antennas available— both commercial and amateur

MISSION COMMUNICATIONS
11903 Allef Clodine Rd #500
Houston, Texas 77082
713-879-7764
telex 166872 MCON UT
(MC/VISA/COD/Amex)

184

Factory-less, jumper-less, ROM-less programming.



With the new **S-COM 5K** Repeater Controller, you'll be able to configure your repeater remotely — using DTMF commands. Only the 5K offers this capability for just $189, wired and tested.

S-COM INDUSTRIES
S-COM Industries
P.O. Box 8921
Fort Collins, CO 80525
(303) 493-8316

185

NEW!
The classic "Antenna Bible" now in a thoroughly-revised, much-enlarged edition

ANTENNAS
2nd edition
by John Kraus, W8JK
Ohio State University

Covers both theory and its applications to practical systems. Over 1000 illustrations and nearly 600 worked examples and problems. Over 100 new topics. Complete with design formulas, tables and references

917 pages, hardcover. $51.95

Add $2.50 per book for shipping and handling U.S., $5.00 elsewhere.

CYGNUS-QUASAR BOOKS
P.O. Box 85, Powell, Ohio 43065
Tel. 614-548-7895

186

TOWERS by ALUMA

HR-2

HIGHEST QUALITY ALUMINUM

- TELESCOPING (CRANK-UP)
- GUYED (STACK-UP)
- TILT-OVER MODELS

T-140 40' Crank-Up Tower

T-40H 40' Heavy Duty Ham Tower Crank-Up

Easy to install. Low Prices. Crank-ups to 100 feet.

EXCELLENT FOR AMATEUR COMMUNICATIONS

Over 36 types aluminum towers made — specials designed and made — Write for details.



SPECIAL
Four Section 50 Ft.
Van Mounted Crank-up
Aluma Tower

ALUMA TOWER CO.
BOX 2806HR
VERO BEACH, FL 32961-2806
(305) 567-3423 803405 MAIN-VERO

187

SPECIALIZED COMMUNICATIONS
FOR TODAY'S RADIO AMATEUR!

Our 20th Year!



Since 1967, covering all modes of Amateur Radio "specialty" communications; Fast Scan TV, SSTV, FAX, Packet Radio, Computers, RTTY, AMTOR, Satellites, TVRO, Microwave, Lasers and more! 10 issues per year. Back issues available, SASE brings TRS80C, C64, IBM software catalog. U.S. subscribers $20/year. Foreign slightly higher. Add $2.00 for Index Issue.

SPEC-COM Communications & Publishing Group
P.O. Box H
Lowden, Iowa
52255-0408

VISA MasterCard
5% Added

low the dimensions given here or in any good antenna manual and you'll get performance and satisfaction.

There are larger CB antennas made on the "quad" principle, and some of these could perform quite well. Quad antenna design is almost a science unto itself and there's not enough space to cover it here. If you get the urge to try one of these, remember these points: frequency of operation is determined by the total length of the wire around the outside of the supports, not the tip-to-tip length of the crossed supports; and, the feedpoint determines whether the polarization is vertical or horizontal. If the feedline is attached at the bottom, the quad will radiate as if it were a horizontal antenna; if fed at the side, it will act like a vertical antenna.

matching

The feed impedance of the driven element in a Yagi antenna can vary from a few ohms up to 100 or so, depending upon element lengths and spacing. A versatile matching device for use with coaxial cable is shown in **fig. 2**. Called a gamma match, it works by providing a variable tap point to the driven element, a variable inductance (the adjustable length of tubing), and a variable capacitance (the smaller tubing that slides inside the larger). To adjust the match for your antenna move the tap point along the driven element an inch or so at a time, then slide the outer section of tubing toward or away from the boom an inch or two and check the VSWR to note whether or not it improved. After making all your adjustments, weatherproof the assembly with clear Krylon.

I talked about power and SWR meters and their use in the January and February 1988 issues of *ham radio*; here's a chance to try them. Get out your hacksaw, drill, screwdriver, and some pieces of aluminum. You'll have some fun building something and using it afterward. (I think I'll follow my own advice and then submit the results as a "Weekender" project! Watch to see how I make out.)

ham radio

flea market

RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance**. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profil organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

TEST EQUIPMENT WANTED. Don't wait — we'll pay cash for LATE MODEL HP, Tek, etc. Call Glenn, N7EPK, at SKAGITRONICS CO. (800) 356-TRON.

MOTOROLA T45 RTA 860 MHz Trunking $450. Several H23, H33, HT 220's VHF low split $100 each. Scott (801) 224-3783.

MACINTOSH SATELLITE Tracking and Propagation Software. MacTrak™ displays graphic maps (rectangular, polar, great circle), views from space, schedules, windows. Also tracks Sun and Moon. Compatible with KLM/MIRAGE rotor interface. Shows gray line, sunrise/sunset, bearing/distrnac,e mUF vs time, areas of world "open". SASE for info or $49.95 from R. Stegemeyer, PO Box 1590, Port Orchard, WA 98366.

TEKTRONIX 547 Oscilloscope, 50 MHz-BP $135, Tek-1A1 $60, Tek-1A4 $120, Tek-1L30 Spectrum Analyzer, 0.9-10.5 GHz $350, Hewlett-Packard 606A Signal Generator, 0.05-65 MHz, $100k, HP-8708A Synchronizer $150, HP-3300A Function Generator $95, HP-686C Sweep Generator, 8-12 GHz $95, HP-9865A Cassette Memory $95. Lambda LB-701-FMOV Variable Regulated Power Supply, 300 amps, new $295. A. Emerald, 8956 Swallow, Fountain Valley, CA 92708. (714) 962-5940.

HALL ELECTRONICS buys radio broadcast equipment for cash! Jon Hall, WB4MMV, PO Box 7732, Charlottesville, VA 22906. (804) 973-8697.

WANTED Old and Unique bugs especialkly looking for Dow Keyw and Vibroplex Zephyr models. Smiley White, WB4EDB, POB 5150, Fredericksburg, VA 22403. (703) 373-0996.

MININEC antenna analysis for IBM-PC. New enhanced version $10. With plotting $35. With antenna and plot libraries $50. See May QST p. 70. K6STI, 507-1/2 Taylor, Vista, CA 92084.

CUSTOM EMBROIDERED EMBLEMS, & Enameled Pins, your design, excellent quality, low prices, free booklet. A.T. PATCH CO, Box 682 Dept 19, Littleton, NH 03561. (603) 444-3423).

BM-PC RTTY/CW. New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

CHARGE
YOUR CLASSIFIED ADS
to your MC or VISA, write or call
HAM RADIO MAGAZINE
Greenville, NH 03048
(603) 878-1441

SELL: AEA PK64A/HFM packet $175. ICOM IC-271A 25W, 2m Xcvr $525. Hallicrafters SX115 Receiver $250. Spectrum Communications 450/2m repeater circuit boards TX/RX $50 each and RF power amplifiers $35 each. VHF Engineering ID $25 and COR $10. Radio Shack Color 3 Computer with RS-232 interface $150. ICOM 251A 2m, 10W multimode Xcvr $300. Floyd Chowning, K5LA, 5637 Prince Edward Avenue, El Paso, Texas 79924. (915) 751-6204.

HAMLOG COMPUTER PROGRAMS. 17 modules auto-logs, sorts 7-band WAS/DXCC. Full features. Apple $19.95, IBM or CP/M $24.95. KA1AWH, POB 2015, Peabody, MA 01960.

DIGITAL AUTOMATIC DISPLAYS. All Radios. GRAND SYSTEMS, POB 2171, Blaine, Washington 98230.

CHASSIS & CABINTS KITS. SASE. K3IWK, 5120 Harmony Grove Rd, Dover, PA 17315.

GIANT POWERSTAT Variable Transformer 240V input, 28 Amps. 0-280V output, 7.8KVA $145, plus ship. Joseph Cohen, 200 Woodside, Winthrop, MA 02152 (617) 846-6312.

COMMODORE/AMIGA CUSTOM CHIPS FOR C64/128 Computer/peripherals at low prices. 24 hour delivery. #6510- $9.95, #6526- $9.95, #6567- $14.75, #6581- $12.85, PLA- $12.50, 901 ROMS at $10.95 each and many others, including Amiga..." The COMMODORE DIAGNOSTICIAN". A complete diagnostic reference chart for fixing Commodore computers, etc. An absolute must for those who want to fix their own computers and save money and downtime. $6.95 plus $1.00 postage... COMMODORE REPAIR. We are the largest/oldest Authorized Service Center in the country. (eg. C64- $39.95). (We ship worldwide). Heavy duty Power Supply for C64- $27.95 plus UPS. Send for complete chips/parts catalog...VISA/MC...Kasara, Inc, 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-642-7634, 800-248-2983 (outside NY) or 914-356-3131.

WANT COLLINS KWM 2/A and accessories. Also looking for other Collins gear. Call after 4 PM EDST (201) 728-7938.

ANTENNA TUNER WANTED. Heath Model SA-2500 only, non-working acceptable. W2BLL, RD 2, Box 72, Boonton, NJ 07005.

WANTED RECEIVERS. (ICOM: IC-745, IC-R7000, Bearcat DX-1000). Scopes and Monitors: Heath: EVW-3 imp scope, SB-620 spect. analyzer, SB-610 monitor. Tektronix: 502A, 544, 546, 547, 549, 556; a relatively new 5 MHz to 10 MHz scope, single channel, do not need time delay; a 500 MHz to 1 GHz scope without the use of sampling. Scope Plug In's: Tektronix. I can use most of the 1 ser. and letter series plug in's, including the spectrum analyzer plug in's, (IL5, IL10, IL20, IL30, IL40) for the 530-, 540-, 550- series main frame. I have a special need for the Type "T" time base plug in. POWER SUPPLIES: Tektronix, type 127, 132, 133. SIGNAL GENERATOR: Hewlett Packard: 606B or 606A, 608F, 608C, 608E, 612A or 610B, 614A, 616B or 616A. FUNCT & SWEEP GEN: Heath: EU-81A, IG-1271, IG-1273, IG-52, IG-1275. NOISF GEN: For the 5 hz to 2 GHz range. STEREO AMPS: Heath: AA-2004, AA-15, AA-1506, AA-1640, AA-2005A, AA-29, AA-1515, AA-1219. POWER SUPPLIES: Heath: IP-17 or IPW-17 or IP17A, IP-2700, IP-2701, IP-28, IP-2718, IP-15, IP-18, IP-2715, IP-12. FILTERS: Receiver audio output filters—tunable; woodpecker noise blanker. PREAMPS: Receiver RF preamps—tunable. WATT METER: B&W 334A dummy load watt meter. VIDEO: Video cameras as used in closed circuit TV. CAR RADIO MOUNT: IIX Equipment Ltd: Mobile radio mount MM1007 or MM10013. ANTENNAS: Wide band scanning antennas for 10 kHz to 2 GHZ. Write to: J.L. Courtney, PO Box 391, Canal Winchester, OH 43110.

CALL SIGN BADGES: Custom license plate holders. Personal, distinctive. Club discounts. SASE. WB3GND, Box 750, Clinton, MD 20735. (301) 248-7302.

FOR SALE: Kenwood TS-820S, digital display. Excellent condition, very clean. $475. Matt, WA1HRE, (203) 693-0468.

PROFESSIONAL QUALITY DTMF Decoder and Select Call System, by Vince Yakamavich, AA4MY, see Feb QST Magazine for details. Blank board #152-PCB only $17.95. Kit of Parts including board, #152-KIT only $69.95. Assembled and tested board #152-ASY only $99.95. Add $2.50 per order S/H. A & A ENGINEERING, 2521 W. LaPalma, Unit K, Anaheim, CA 92801. (714) 952-2114.

ANALOG AND RF CONSULTING for the San Francisco Bay area. Commercial and military circuits and systems. James Long, Ph.D., N6YB (408) 733-8329.

WANTED: Klystron tubes especially 2911; Magnatrons; also 304TL, 6012, 810 and 5CX1500A. All types of sockets for transmitting tubes. Harold Bramstedt, 6104 Egg Lk Rd, Hugo, MN 55038. (612) 429-9397.

UHF PARTS. GaAs fets, mimics, chip caps, trimmer caps, and other builder parts. MGF 1402 @$14.00. MFG 1302 @$10.00. .8-10pf Trimtronics trimmer @$3.75. Porcelain chip caps @$1.75. Orders add $1.00 p+h. SASE for complete list. MICROWAVE COMPONENTS, 11216 Cape Cod, Taylor, MI 48180.

JENNINGS UCS-300-7.5 KV variable vacuum capacitor $135, RJ1A/HC-1 vacuum relay $75, RJ2C $140. Cardwell 2100pF-3 KV variable capacitor $45. Eimac 3CX1200A7 $375, 4CX3,000A $675, 4CX5,000A $950, SK-2210/SK-2216 $85. Centralab 858-1000pF $5 ea. (All new). A. Emerald, 8956 Swallow, Ftn. Vly, CA 92708 (714) 962-5940.

MACKET: Macintosh packet program, $39.95. For details write to S. FINE SOFTWARE, POB 6037, State College, PA 16801.

PHOTOVOLTAIC PANELS. Lowest prices on Sovonics, Arco panels. From 1 watt to 50. Send $1 for price specs and data sheets. Michael Bryce, 2225 Mayflower, Massillon, Ohio 44646.

RTTY JOURNAL—Now in our 36th year. Read about RTTY, AMTOR, PACKET, MSO'S, RTTY CONTESTING, RTTY DX and much more. Year's subscription to RTTY JOURNAL $10.00, foreign slightly higher. Order from: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

MARCO: Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224. (213) 774-1255.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC, ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

BRITISH COLUMBIA: July 8-10. The Okanagan Ham Society is sponsoring the annual Okanagan Ham Fair, Illahie Beach RV Park, Hwy 97 N., Summerland, BC. 4 PM Friday to 4 PM Sunday. Admission $5.00. Flea market, auction, new equipment, surplus and more. Talk in on 146.34/94 or 146.52. Contact VE7GSB, Glenn Borgens at (604) 492-5684 or write Okanagan Ham Fair, Box 477, Penticton, BC, Canada V2A6K6 or VE7BEE at (604) 493-1122.

WISCONSIN: July 9. Swapfest '88 sponsored by the South Milwaukee ARC, American Legion Post 434, Oak Creek. Starts 7 AM. Tickets $3. Amateur Radio exams. Talk in on 146.58, WA9TXE/9.

OHIO: July 10. The Wood County ARC is sponsoring their 24th annual Ham-A-Rama at the Wood County Fairgrounds, Bowling Green. 8 AM to 4 PM. Free admission. Tables $7.00. Trunk sales $3.00. Foor and drink available. Talk in on 147.18/78 and 146.52. For more info contact Jim Davis, N8DWR, 10990 Newton Rd, Bowling Green, OH 43402. (419) 352-3321.

ILLINOIS: July 10. The DuPage Amateur Radio Club is sponsoring a Hamfest/Computer show, American Legion Post 80, 4000 Saratoga, Downers Grove. Admission $3/gate or $2/advance. Gates open 8 AM. Outdoor flea market and swappers row, indoor tables, VEC exams for all classes. Talk in on 146.52, 145.250-600, 224.55 and 442.55. For tickets or reserved tables SASE to Hamfest Chairman, W9DUP, PO Box 71, Clarendon Hills, IL 60514 or call (312) 985-0527 evenings or weekends.

NEW YORK: July 10. The 8th annual Batavia Hamfest sponsored by the Genesee Radio Amateurs, Alexander Firemen's Grounds, Rt 98, Alexander. 6 AM to 4 PM. Indoor exhibits open 9 AM. OM/YL programs, spacious flea market, chicken BBQ, free camping, VEC exams. Advance tickets $3 before July 1. $4/gate. Talk in on 144.71/145.31 and 146.52. For information G.R.A.M., POB 572, Batavia, NY 14021. For tickets Knute Carlson, N2DRX, 26 Burke Drive, Batavia, NY 14020.

MAINE: July 16. The First annual Mid-Coast/Yankee Hamfest, Union Fairgrounds, Union, midway between Augusta and Rockland. Tailgating, swap table space (bring your own tables), demonstrations, crafts, food and entertainment. Lobster dinner at 1 PM Saturday. Camping available Friday and Saturday. Talk in on 146.385/985. For more info Carl Ingerson, N1DXM, PO Box 929, Union, Maine 04862. (207) 785-4948 or on packet via KA1FKS-1 on 145.03.

NEW JERSEY: July 17. The Sussex County ARC will sponsor "SCARC '88", Sussex County Fairgrounds, Plains Road, off Rt 206, Augusta. Doors open 8 AM. Registration $3.00. Indoor tables $7.00 each. Tailgate space $5.00. Food and refreshments. Plenty of free parking. For more info write Don Stickle, K2OX, Weldon Road, RD 4, Lake Hopatcong, NJ 07849. Tel: (201)-663-0677.

MISSOURI: July 17. The Zero Beaters ARC is sponsoring their 26th annuyal Zero Beaters Hamfest, Bernie H., Hillermann Park, Washington. 7 AM to3 PM. Free admission. Parking $2. for Flea Market. FCC exams. Talk in on 84/24 and 52. For information Al Lanwermeyer, WB0QBS, (314) 239-2072.

ILLINOIS: July 17. The Fox River Radio League's annual Hamfest, Pheasant Run Lodge, North Avenue, St. Charles. Doors open 8 AM. Advance tickets $4 plus SASE to Phil Fors, N9FXQ, 104 May Street, West Chicago, IL 60185. Indoor/outdoor flea market. VEC exams. Free parking. Fly in to DuPage County Airport. Talk in on 145.470-600 and 1465.210-600. Commercial and inside tables contact Kermit Carlson, W9XA, 36W345 McKee Rd, Batavia, IL 60510.

ILLINOIS: July 23-24. The Amateur Cross Link Repeater Club is having its 2 day Hamfest and Banquet, DeVry Institute of Technology, 3300 N. Campbell, Chicago. Advance tickets $3; $4/door. Setup 7 AM. Doors open 8 AM. Outdoor flea market sellers bring own tables. Indoor dealers tables provided. Banquet $15. Guest speaker Gordon West, WB6NOA. For tickets SASE to Peter Hughes, WB9EYR, 3315 N. Oakley, Chicago, IL 60618. For more information call (312) 712-5100. Talk in on 147.225, 224.480 and 443.700.

INDIANA: July 20-24. The County Hunters 20th annual convention, Ramada Inn-South, Indianapolis. All Amateurs are welcome to attend and participate in the various activities. Tours of Conner Prairie Settlement and the Indy 500 Motor Speedway highlight the week. Interested Amateur should SASE for information and registration forms to Herb Morgan, WD9GBH, 735 East 50th Street, Marion, IN 46953.

NEW JERSEY: July 31. The WA2WEB East Coast VHF Society's *annual Antenna Gain Measuring Contest and Flea Market*, Trenton State College, Ewing Township, Trenton. 8 AM. Flea Market Handicap and Wheelchair accessible. Free registration and parking. Talk in on 146.67- (W2ZO/R). For information SASE to Russ Pillsbury, K2TXB, RR 7, Oakshade Rd, Tabernacle, NJ 08088 (609) 268-9586.

ILLINOIS: July 31. The 54th annual Hamfest sponsored by the Hamfesters Radio Club, NEW LOCATION—Will County Fairgrounds, Peotone. 5 AM to 3 PM DST. Admission $3/advance or $4/door. FCC exams, overnight parking. Nearby camping. Displays, swappers row. Talk in on 146.76/16 and 146.52. Club call W9AA. For tickets send check or MO in No.10 SASE to Hamfesters Radio Club, 13058 Finch Ct, Lockport, IL 60441. For information John Schiptsch, W9ENR, 13058 Finch Ct, Lockport, IL 60441. (312) 403-1043.

OPERATING EVENTS

"Things to do . . ."

OKLAHOMA: July 9-10. "Field Day" exercises conducted by Oklahoma Amateur Radio Operators at Lake Canton. Activities begin 3 PM Saturday and continue through the night until noon Sunday at the "Big Bend" picnic shelter in conjunction with the annual IARU "Radiosport" DX Contest. To highlight this special events, the Lake Canton Field Day Committee will provide a commemorative certificate for contacts with event stations WD5HPU, WA5LTM and other Amateur stations. Listen in the General phone portions 40-10m. Also 6 and 2m SSB.

INTERNATIONAL HAMFEST. July 7-9. VE4IHF will be in operation to help celebrate the 25th anniversary of the International Hamfest held in the Peace Gardens on the Manitoba, Canada, and North Dakota, USA border. 9 AM CST to 9 PM CST. To receive the "Peace Garden Award" send a QSL and 3 IRC's along with SASE to VE4XN, Dave Snydal, 25 Queens Crescent, Brandon, Mnnitoba, Canada R7B 1G1.

NEW YORK: July 23 and 24. The Oswego County Amateur Radio Emergency Service (ARES) and the Fulton ARC will operate KY2F, 1500Z to 2300Z each day from the Oswego County Air Show. Lower third of General 40, 20, 15, 10 and 2m bands *and Novice portion of 10m. For certificate send large SASE to* Fred Swiatlowski, KY2F, PO Box 5227, Oswego, NY 13126.

MARYLAND: July 23-24. The Laurel ARC will operate special event station W3GFS from 1800Z 7/23 to 1800Z 7/24 from a small uninhabited island in Chesapeake Bay the world's largest estuary. Freqs: Lower 25 kHz of General 80-10m and 147.54. Attractive 8x11 certificate for SASE. QSL to LARC, PO Box 1436, Laurel MD 20707.

July 23-29: The Long Island Mobile ARC will operate special event station W2OOVL. CW and phone on all HF bands. QSL with SASE via WA2KXE, 162 West Hudson Street, Long Beach, NY 11561.

HAM RADIO TODAY has joined the programming lineup from the Voice of the Andes, HCJB Radio, an international broadcasting station that has been operating from Quito, Ecuador since 1931. Programming includes news from all over the world, construction hints, propagation news, equipment reviews and much more. For more information contact John E. Beck, Producer, HAM RADIO TODAY, c/o HCJB Radio, Box 691, Quito, Ecuador, SA.

HAM EXAMS: The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday JUNE 22, 7 PM, MIT Room 1-150, 77 Mass Ave, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 646-1641. Exam fee $4.50. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 available from the FCC in Quincy, MA (617) 770-4023.

SUBSCRIBE
AND RENEW
TOLL-FREE



ham radio magazine

1 YR - $22.95 2YRS - $38.95

3 YRS - $49.95

Prices U.S. only

☐ MASTERCARD
☐ VISA ☐ BILL ME

Please have your charge card ready.

DATATEL 800™

800-341-1522

Weekdays 8 AM - 9 PM EST • Saturdays 9 AM - 5 PM EST
IN MAINE CALL COLLECT (207) 236-2896

OUR 800 NUMBER IS FOR SUBSCRIPTION ORDERS ONLY!

For Errors or Change of Address CALL *ham radio*
direct at (603) 878-1441 8-5 EST

AUGUST 1988 / $2.50

ham radio magazine







Amateur Radio Stamps

from Around the World





hr
focus on communications technology

ham radio magazine

AUGUST 1988

volume 21, number 8

T. H. Tenney, Jr., **W1NLB**
publisher
and editor-in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
production editor

Peggy Tenney, KA1QDG
copy editor

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., **N1ACH**
assistant publisher

Rally Dennis, KA1JWF
director of advertising sales

Henry S. Gallup, KA1RYG
advertising sales manager

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Phil Alix, KA1IDP
traffic manager

Farm Color
cover

ham radio magazine is published monthly by
Communications Technology, Inc.
Greenville, New Hampshire 03048-0498
Telephone: 603-878-1441

subscription rates

United States
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail),
one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 93

Microfilm copies are available from
University Microfilms, International
Ann Arbor, Michigan 48106
Order publication number 3076

Cassette tapes of selected articles from *ham radio* are available to the blind and physically handicapped from Recorded Periodicals,
919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1988 by Communications Technology, Inc.
Title registered at U.S. Patent Office

Second class postage paid
at Greenville, New Hampshire 03048-0498
and at additional mailing offices
ISSN 0148-5989

Send change of address to *ham radio*
Greenville, New Hampshire 03048-0498

contents

10 a 4800 baud modem for VHF/UHF packet radio
Glen Leinweber, VE3DNL,
Max Pizzolato, VE3DNM,
Jon Vanden Berg, VE3DVV,
and Jack Botner, VE3LNY

22 one hundred years of electric waves
W. Clem Small, KR6A

27 practically speaking: impedance matching
Joe Carr, K4IPV

34 the Quad antenna, part 3, circular loop and octagonal arrays
R.P. Haviland, W4MB

54 remote base/simplex phone patch controller
Roger Owens, AA4NX and
Jeff Owens, KK4LA

70 ham radio techniques: the joys of TVI or, were you on the air last night?
Bill Orr, W6SAI

75 precision high-voltage dc regulator
R.L. Measures, AG6K

81 Elmer's notebook: propagation basics
Tom McMullen, W1SL

Joe Reisert is on vacation.

on the cover: Amateur Radio stamps from around the world from the collection of Raymond Schuessler a philatelist from Venice, Florida.

98 advertisers index
9 comments
88 DX forecaster
96 flea market
92 ham mart
48 &
53 new products
98 reader service
4 reflections

REFLECTIONS



Let's dust off that used equipment!

We received some interesting letters following Joe Schroeder's June editorial "Novice enhancement and the future of Amateur Radio." Some lamented the relatively high cost of new equipment and others felt, like Joe, that the best bet would be a market survey asking present and former operators what helped or hindered their developing Amateur Radio interest. One ham, returning to the hobby after 20 years, found the latest equipment to be reasonably priced and of good quality.

Novice enhancement has given beginning Amateurs increased operating privileges, but can they afford the cost for new equipment to get on the air? Someone just starting in the hobby may not want to sink a small fortune into his rig until he knows what he really wants. And how much does a Novice really need: a radio that covers 10 through 80 meters, CW and SSB capabilities — that's about it. This may seem like an oversimplification, but how many Novices need all the bells and whistles? For those who can afford it fine; for those who can't...

Here's a pitch for you. A good majority of us have lurking in our basements a veritable storehouse of used equipment. Stuff that we've outgrown as we've upgraded our shacks. It's my bet that there are numerous Novices out there that would just love to put this equipment to use. Starting immediately, on a space available basis, we'll run free classified ads for our subscribers to sell old, used equipment. Here's a perfect opportunity for you to help a new ham get on the air.

You don't want to sell it? Then why not become an Elmer and help that new ham by lending him your perfectly good, but long forgotten, transceiver along with some assistance in establishing his first station?

How many of you remember your first station? I'm sure most of us can credit a certain special person (our Elmer) for his invaluable time and assistance in helping us to put that first, hesitant CQ on the air. I know I do...thanks Bill, K1BH.

Marty Durham, NB1H
Technical Editor

As you can see by the enclosure, we're hard at work on the new Ham Radio Magazine. We think you'll be excited by it. Your suggestions in informal surveys have resulted in a major effort on our part to make HR the magazine you want. Every month there'll be at least two projects of the weekender type — simple, easy-to-build ideas that will add to your Amateur operation. New layout, fresh graphics and plenty of surprises are in store for Ham Radio readers.

Your input is most important to us. Let us know what you think. Starting next month, there'll be an evaluation card for you to fill out and return. So, after you've been through the September issue, send a note, call, or look us up at a show. We'll be waiting to hear from you.

comments comments

re-discovering ham radio

Dear HR:

I found the "Reflections" editorial in the June 1988 issue to be very interesting. I am one of the very new Amateurs you mention, and have come back after retirement, having let my General ticket expire in the 60s.

I would point out that the "well-established" factor is probably a very important one, because the basic cost of ham gear is quite high, compared to (say) photography. Also, as to why guys drop-out, I can tell you that it was the same very high cost of SSB gear that discouraged me from hanging-on when I was younger and had lots of very important growing-family expenses.

My surprise in finding that SSB gear was so good, and reasonably priced in CB units is one of the main things that got my interest up again! And, sure enough, I found one rig that did a very neat job, at quite reasonable cost! I'll hand that along to my daughter, hopefully, now that I've upgraded my equipment.

I really had no idea just how very good the gear can be today; or how very astute the average hams on-air are! I tend to do a lot of listening, and find that there are so very many guys who are actively involved in evaluating and improving their antennas, feedlines, tuners, etc. I have also read a lot of the detracting comments by the QRP people and have an old friend who is a CW freak.

It really seems to me to be a pretty healthy mix, except for the few bad-actors. Your comments on putting the situation in the hands of professionals seems reasonable. I suggest that really believable illustrations showing rig setups and compact beam antennas would help get people to pick up more of the magazines, and commence the day-dreams that lead the way!

Yours was the very first ham magazine that I started buying, again...then subscribed to, for I didn't want to miss any. I give you the highest marks on all accounts.

As a matter of general interest, I'd like very much to see a no-holds-barred comparison review of the hf linear amps available, as many as possible! I've heard lots of comments on amps, and rigs in general on-the-air, and have been very glad that I paid attention!

Ralph Marler, KC1JG,
Portsmouth, New Hampshire
03801

legal usefulness of amateur radio

Dear HR:

I disagree strongly with Joe Schroeder, W9JUV, in his "Reflections" in the June issue. Amateur Radio as we know it really does need an overhaul or it simply won't sell, market survey or no.

The problem is not Novice enhancement nor the current licensing structure. It lies in our extremely narrow definition of "Amateur". As it stands, in spite of the marvelous technical capability we have, Amateur Radio is useless as a service to the average person on the streets. Case in point: June 1988, *QST*, page 78 states that ordering a pizza via local autopatch is illegal because it is a "business communication". If I can't do something as trivial as that via Amateur Radio, what good is it?

People buy things because they are useful. Up to a point you can sell people on something that doesn't meet a real need, but not very long and not very many. If we were to broaden the definition of "Amateur" to permit the kind of communications that most people want on domestic frequencies (VHF and up, no international communications) we would find a lot of response out there. If I could order a pizza, talk to my wife about who has called in while I was out on a sales call, talk about my business (short of advertising on the air), it would be useful, and I could recommend it to my friends and encourage them to get involved. Now I suggest buying a cellular phone.

I have long been involved in Amateur Radio because I enjoy the technical aspects of it. But after the thrill of talking beyond the sound of my voice wears off, I look for usefulness. Perhaps I am spoiled. I returned recently from several years on a large island in the Pacific. Four hf frequencies tied over two hundred families together across several hundred miles of impassable jungle. We arranged transportation, ordered groceries, flight followed aircraft, managed people, all under difficult conditions. I know what radio is like when it is useful.

I am convinced that unless Amateur Radio in the United States is opened up to more legal usefulness, it simply will not be there when the emergencies arise, and our frequencies will be taken away.

Bill McLagan, WA7AQN,
Corvallis, Oregon 97330

market survey of Amateurs good idea

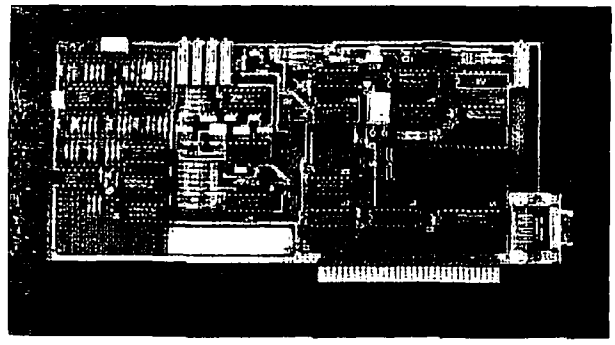
Dear HR:

I strongly support portions of Joe Schroeder's June 1988 Reflections! I am especially in agreement with his comments about marketing and marketing analysis.

New, Amateurs, younger ones in particular, must have a difficult time understanding how to operate today's overly sophisticated transceivers during early entry into operating. Perhaps a worse consideration for a beginner is the price tag associated with even the lowest priced modern rigs. We have entered into an era of $6,000+ transceivers, and the bottom of the scale is on the order of $1,000. It is not difficult to visualize the shock coeffi-

(continued on page 94)

Fast, reliable modem cuts connect time



a 4800 baud modem for VHF/UHF packet radio

Do you sometimes feel guilty of hogging your local packet network when you have a large file or message to transfer? Here's a modem that can cut down on your connect time.

A wide variety of radios now work with this modem. Reliability is high enough that our local digipeater (VE3PKT) has been switched exclusively to 4800 baud and has been running trouble free for many months. We will show how you can add a 4800 baud modem to the HAPN-1 packet radio adapter. It fits nicely into the card's "prototype area" for experimenters.*

A software switch provided with the HAPN-1 adapter lets you change from the standard (built-in) 1200 baud modem to this one. The interface between the packet card and radio is arranged to accommodate both modems; all it takes to switch from one speed to the other is a keyboard selection.

Although the bandwidth used in VHF and UHF voice operation could support data rates higher than 4800 baud, HAPN chose 4800 baud for the following reasons:

- Most existing VHF or UHF radios can be used.
- No major changes to your radio or TNC (terminal node controller) should be required.
- Alignment and setup should be easy.
- It uses no exotic or difficult to obtain parts.
- It uses the same bandwidth as normal 2-meter voice operation.
- 4800 baud provides nearly four times the effective data rate of 1200 baud.

The modem contains an on-board squelch circuit that activates in approximately 10 milliseconds, typically 10 to 30 times faster than the squelch in most radios. As a result, clear-to-send delays (Tx-delay) and turnaround times are shorter, reducing "wasted channel" time.

principles of operation

Most packet radio TNCs include a modem; other telecommunication groups treat the modem as a separate entity. Its purpose is to transform the serial, digital data into a form compatible with the transmitting medium — in our case, a VHF 2-meter radio. It also must take a noisy, undulating voltage from the radio receiver and change it into a digital data stream acceptable to the TNC. Our current packet radio system requires the TNC to know when the radio channel is in use; this is the modem's job too.

transmitting duobinary codes

The digital data coming into the modem is a stream of ones and zeroes that modulate the transmitter's rf

*The HAPN-1 adapter is a terminal node controller on a board that plugs into a slot on an IBM PC or compatible microcomputer.[1] HAPN is also designing a version to work with the TAPR TNC-2 compatible unit. It will reside on a "daughter board" that plugs into J4, a connector provided by TAPR for an external modem, and work off a single +12 volt supply. The board will contain a multiplexer making it possible to switch between 1200 and 4800 baud easily. This board is currently in the prototyping stage.

By Glen Leinweber, VE3DNL; Max Pizzolato, VE3DNM; John Vanden Berg, VE3DVV; and Jack Botner, VE3LNY; Hamilton and Area Packet Network, Box 4466, Station D, Hamilton, Ontario, Canada L8V4S7.

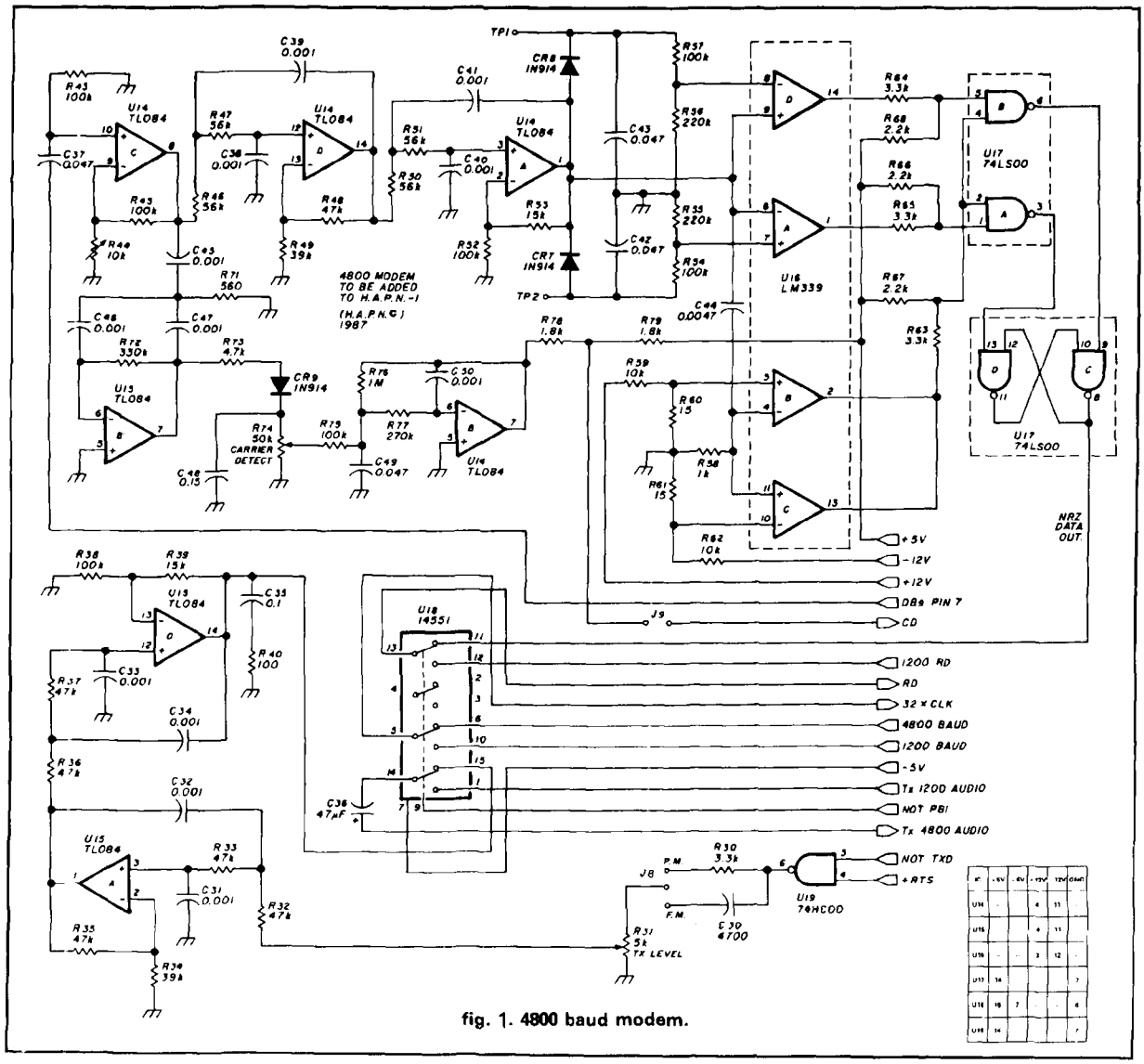


fig. 1. 4800 baud modem.

carrier. This modem uses a duobinary coding system where a 0 to 1 transition momentarily shifts the carrier *up* in frequency, then back to center. The carrier is shifted *down* in frequency and then back to center by a 1 to 0 transition. If two or more consecutive ones come along, the carrier shift occurs only for the first 1, returning back to center for the rest. Similarly, a string of two or more zeroes shifts the carrier down in frequency only for the first 0, returning to center for the rest. Because the frequency of the carrier is changed in frequency only for the first 0, returning does not require a data randomizer to avoid data-sensitivity errors caused by the carrier drifting from the center of the channel.

All these transitions are smoothed out by a four-pole low-pass filter before they reach the radio's modulator. The filter prevents spurious sidebands from interfering with adjacent channels (see **fig. 1**). The shape of the waveform going into the rig's modulator must be carefully controlled. Most rigs amplify the microphone signal with rather nonlinear amplifiers that can severely distort these waveshapes. You can get the best results when the signal is tapped into the frequency modulator directly, bypassing the rig's audio stages.

What happens with a rig using a phase modulator? A phase modulator can be accommodated by modifying the shape of the waveform input. A jumper, J8, in the modem chooses one of two waveshapes to be filtered for either frequency (FM) or phase (PM) type

modulators. This modulation scheme works well with frequency synthesized radios. Tap points in both receiver and transmitter that work for this modem also seem to work for 1200 baud modems.

receiving duobinary codes

After getting into the receiver, the frequency-modulated signals pass into the radio's FM detector. Every detector type (ratio detector, quadrature, etc.) yields the same shape waveform. It will be the same shape whether it is generated from a PM or FM modulator (**fig. 2**). The voltage waveform output is proportional to the frequency excursions of the transmitting signal — positive pulses returning to zero and negative pulses returning to zero. The receiving part of the modem must discriminate between positive-going pulses, no pulses, and negative-going pulses.

After amplification by U14c, the signals are filtered by a four-pole low-pass filter which reduces high-frequency noise (U14d and U14a). Comparators (or slicers) U16d and U16a detect positive and negative going pulses, respectively. U16b and U16c together output a short digital pulse at the center of either positive or negative pulses. These digital signals are combined in U17, which reconstructs the original data.

As with the transmitter, the signal coming out of the receiver's detector must have the correct waveshape. The audio de-emphasis circuit (usually placed immediately after the detector) will distort the pulse shapes enough to cause unreliable operation. This means that tapping the receive signal from the volume control or speaker won't work.

carrier detect

Our packet radio protocol states that if a channel is busy, one shouldn't begin a transmission. Squelch circuits found in every FM radio duplicate this function. The carrier-detect circuit in this modem works much like the squelch, but rather than muting the audio it generates a logic signal for the TNC.

This is a noise-operated circuit. U15b detects high-frequency audio noise (approximately 11 kHz) where neither audio nor modem pulse energy is present. With no carrier present, there's lots of high-frequency noise to raise the voltage at R74. Smoothing this pulsating waveform is U14b, a low-pass filter. It drives a Schmidt trigger (U3 in the HAPN-1 adapter) logic gate that makes a quick, clean, carrier/no carrier decision.

At these higher bit rates, the switching time from transmit to receive and back becomes more important. In some radios much of this time is wasted by slow squelch action. This one reacts in 10 to 15 milliseconds.

modem switch

A four-pole, two-position electronic switch, U18, is

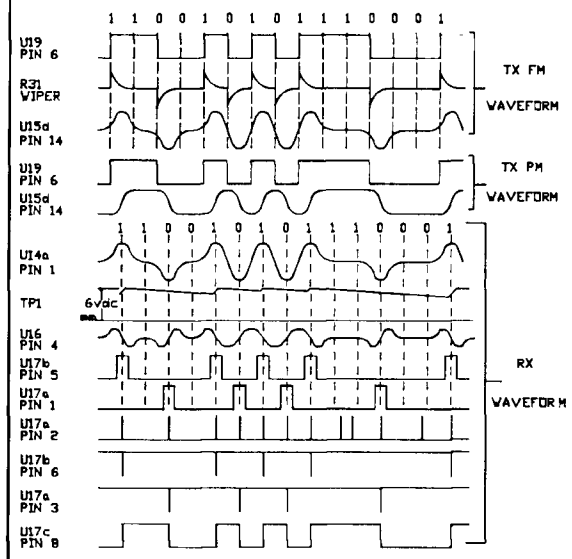


fig. 2. Timing and waveshapes for the 4800 baud modem. Amplitudes are not drawn to scale. There are two possible transmit waveshapes, one for FM and one for PM modulators.

Parts list

Resistors	*1/4 watt, 5 percent*
R60,R61	*= 15*
R40	*= 100*
R71	*= 560*
R58	*= 1k*
R78,R79	*= 1.8k*
R66,R67,R68	*= 2.2k*
R30,R63,R64,R65	*= 3.3k*
R73	*= 4.7k*
R59,R62	*= 10k*
R39,R53	*= 15k*
R34,R49	*= 39k*
R32,R33,R35,R36,R37,R48	*= 47k*
R46,R47,R50,R51	*= 56k*
R38,R43,R45,R52,R54,R57,R75	*= 100k*
R55,R56	*= 220k*
R77	*= 270k*
R72	*= 330k*
R76	*= 1 M*

Potentiometers = 3386W Type 3/8 square single-turn adjustment
R31 = 5k
R44 = 10k
R74 = 50k

Capacitor voltage rating: at least 16 volts, 10 percent tolerance or better and to have spacing of 0.2".

C31,C32,C33,C34,C38,C39,C40, C47,C50	*= 1000 pF*
C30,C44	*= 4700 pF*
C37,C42,C43,C49	*= 0.047 µF*
C35	*= 0.1 µF ceramic bypass*
C48	*= 0.15 µF*
C36	*= 4.7 µF tantalum*

Diode = Switching /signal-silicon
CR7,CR8,CR9 = 1N914 or 1N4148

Jumpers
J8 = three post jumper
J9 = two post jumper

Sockets = 5 x 14 pin
Sockets = 1 x 16 pin

Integrated circuits
U14 = TL084
U15 = TL084
U16 = LM339
U17 = 74LS00
U18 = 14551
U19 = 74HC00

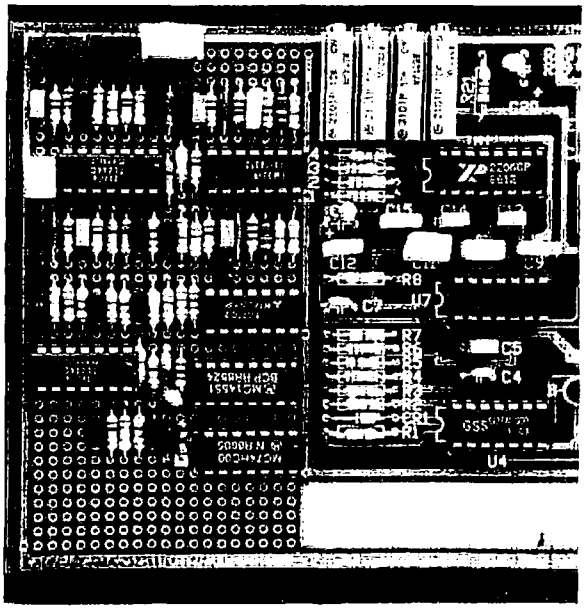


photo A. Close-up of the 4800 baud modem on the HAPN-1 prototype area.

included to allow software switching from one modem to the other. A logic signal from an unused output line of the 8273 (U6, pin 36) controls the switch.

Since each modem operates at a different bit rate, one of the poles switches the 8273's 32X clock (pin 25) input from the standard 1200 baud position to the 4800 baud position. Another switch position selects the digital data output from one modem or the other. The serial data comes from the switch's pole into the 8273 data input (U4, pin 13).

Because this is a MOSFET switch, it can deal with analog and digital signals. The transmit signal going to the rig's modulator can be routed from one modem or the other by the third switch. Turning the 8273 control port (port B) bits on and off puts the switch under software control. The node customization program supplied with the HAPN-1 adapter provides a modem select menu; choose the modem/baud rate by pressing one of the function keys. The modem/baud rate remains in effect until the customization procedure is used to change the selection again.

construction

The prototype area at the end of the HAPN card is the perfect place to build this modem. (See **photo A.**) Power supply lines (+12 volts, −12 volts, +5 volts, −5 volts) are available, as are all the TNC interface points. Interfacing is shown for the HAPN-1 card; later versions of the card have traces to the interface points brought out to the prototype area, making modem construction a little easier.

You must use small components. The parts layout

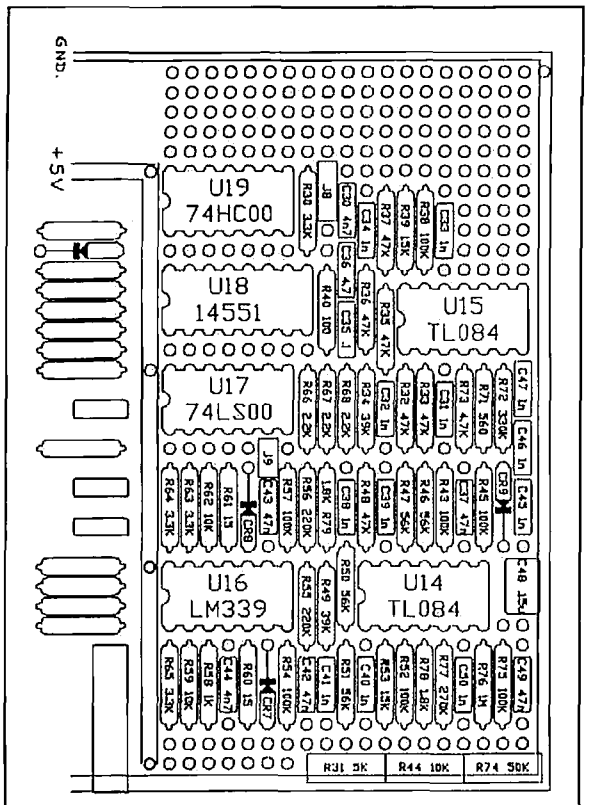


fig. 3. Parts layout diagram from the top of the prototype area.

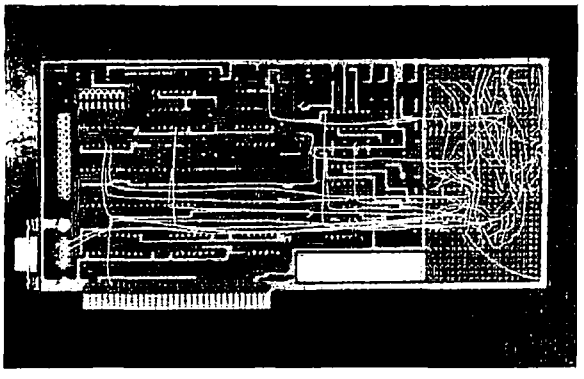


photo B. Bottom of the HAPN-1 adapter showing the wiring added for the 4800 baud modem.

in **fig. 3** assumes all capacitors have a lead spacing of 0.2 inch. Resistors of 1/4 watt have their leads bent to 0.4 inch.

Insert the components according to the layout diagram, and solder them to the board. Then cut the leads off and make the interconnections. A small soldering iron and fine wire (like wire-wrap wire) are a must. Take care with the interconnections; the parts

Table 1. Modem pin designations on HAPN series boards

Signal name	HAPN-1	HAPN-1.1	HAPN-1.2
Rx 4800 audio	DB-9 pin 7	square pad 01	square pad 01
Tx 4800 audio	DB-9 pin 8	square pad 02	square pad 02
−12 volts	C22/R20	square pad 03	square pad 03
32xCLK	U6 pin 25	square pad 04	square pad 04
1200 baud	U8 pin 4	square pad 05	square pad 05
4800 baud	U8 pin 3	square pad 06	square pad 06
Not TxD	U6 pin 29	square pad 07	square pad 07
+RTS	U9 pin 12	U9 pin 12	square pad 08
+12 volts	U11 pin 4	square pad 08	square pad 09
+5 volts	5volt rail	square pad 09	square pad 10
Tx 1200 audio	DB-9 pin 4	square pad 10	square pad 11
1200 RD	U7 pin 7	square pad 11	square pad 12
RD	U4 pin 13	square pad 12	square pad 13
Not PB1	U6 pin 36	square pad 13	square pad 14
CD	U3 pin 9	square pad 14	square pad 15
−5 volts	edge connector B5	square pad 15	square pad 16

Note: Edge connector pin B5 is the fifth pin from the bracket going to the fifth hole on the top row.

are placed very close together and finding a wiring mistake after the modem has been assembled is no fun. (See photo **B.**)

Cut the following two printed circuit traces so the multiplexer chip (U18) can switch from one modem to the other under program control:

1. Cut the default 1200 BPS trace at "SW" (next to P1).
2. Cut the trace going to U4 pin 13. This will be at different locations, depending on the board revision you have:

- HAPN-1 — fat trace on the component side, going to U4 pin 13.
- HAPN-1.1 — short trace between square pad no. 11 and square pad no. 12.
- HAPN-1.2 — short trace between square pad no. 12 and square pad no. 13.

Table 1 shows how the new modem interfaces with different revision boards. The later boards have been enhanced with pads at the prototype area making it easier to add the modem. Square pads are immediately adjacent to the prototype area, in a vertical row. They are consecutively numbered from the top of the board to the bottom.

voltage hookup

Look up the signal name in table **1** and locate the appropriate interface point for your board.

GND — from any wide ground trace at the side of the prototype area to U17 pin 7, U18 pin 8, and U19 pin 7. Also complete ground side connections to all components needing ground (see schematic, fig. **1**).

+12 volts — to U16 pin 3, U14 pin 4, and U15 pin 4. Also connect +12 volts to R59.

−12 volts — to U16 pin 12, U14 pin 11, and U15 pin 11. Also connect −12 volts to R62.

+5 volts — to U17 pin **14**, U18 pin 16, and U19 pin 14. Also connect +5 volts to R66, R67, R68, and R79.

−5 volts — to U18 pin 7.

Finally, make up a cable for the radio with the following:

- "Rx audio" to DB9 pin 7
- "Tx audio" to DB9 pin 8
- "PTT" to DB9 pin 1
- "GND" to DB9 pin 3

modem/radio interface

One project goal was to maintain the functionality of the existing modem while allowing easy switching between the two. It was also desirable to keep the interface between the modem and the radio as simple as possible.

A quick survey of local hams shows that most would have to change the tap points into their radio for the new modem. *Choose the wrong tap points and this modem will not work!* At this time a wide variety of radios have been adapted successfully with little modification.

transmitter interface

The 4800 modem transmit signal must go directly to the FM or PM modulator in your transceiver. Connections to the microphone jack will not work. Tapping at this point also seems to work well with 1200 baud modems, as long as the level is readjusted to match the new tap point. Because this tap point bypasses the limiter stages in the audio chain, take care not to over-deviate. Deviation should be kept to about 3 kHz by adjusting R31 on the modem. Use shielded cable to connect the modem to your radio.

If you choose the correct tap point, your radio will still operate properly when used for voice work but

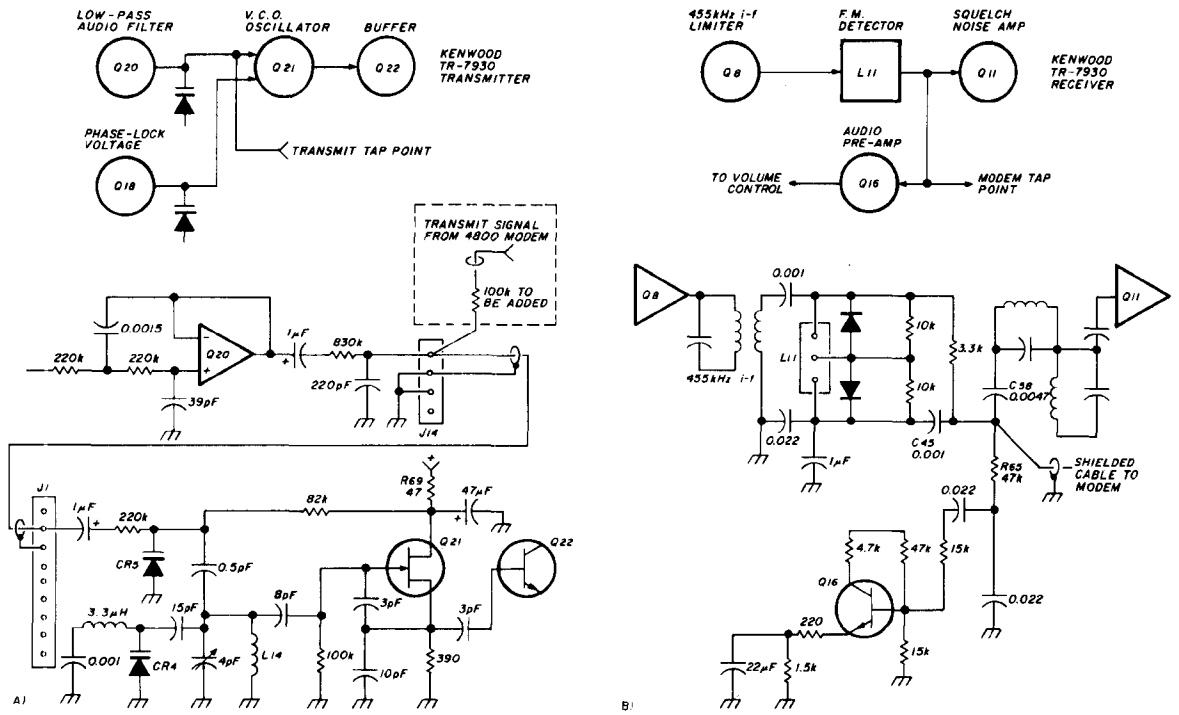


fig. 4. interface of 4800 baud modem to Kenwood TR-7930 rig. This is typical of many rigs in use today. Find the modulation stage in the transmitter (A), and the FM demodulator in the receiver (B).

you will have to disconnect the modem interface cable to get full voice modulation. When it is used for packet communication, it's a good idea to unplug the microphone to prevent room noise pickup.

You must determine which modulation type your radio uses. If you have a phase modulator, install a jumper between the center pin of J8 and the pin connected to R30. If your rig uses a frequency modulator, install the jumper between the center pin of J8 and C30.

Many radio manuals include a block diagram. This is a useful guide to determine what form of modulation your radio uses. FM is always applied to an oscillator circuit; either a crystal-controlled oscillator or a voltage-controlled oscillator (VCO). If it's FM, your rig's schematic will show a voltage variable capacitance (varactor) diode coupled closely to the frequency determining inductors and capacitors (or crystal) of an oscillator circuit.

Phase modulation is always applied to a stage following an oscillator, never to the oscillator itself. PM could be produced using either a voltage variable capacitance diode or a transistor stage called a "reactance modulator".

The point in your radio where the Tx audio should be introduced must be very close to the modulator. Your rig's audio processing stages will probably end in a low-pass filter before going into the modulator. The tap point will be between the low-pass filter and the modulator itself. If possible, tap in at a high impedance point; the modem shouldn't have to drive an impedance lower than about 400 ohms.

Figure 4A shows an example of the transmitter interface to a Kenwood TR-7930 transceiver.

receiver interface

You cannot use a connection into your rig at the speaker or volume control for this modem. Your rig must be tapped directly at the FM detector before the audio is de-emphasized. The de-emphasis circuit (a resistor/capacitor combination) is rarely identified on schematic or block diagrams. It nearly always follows the squelch pickoff point, but is often placed before any audio gain stages.

Most radios use a squelch circuit called a "noise-operated squelch" that gets its operating signal from the FM detector, before de-emphasis. Tap for the modem at *exactly* the point where this squelch circuit joins the FM detector. The input circuit of the modem is ac coupled, and is high impedance (100k). It can

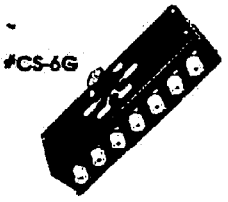
coaxial R. F. antenna switches

Heavy Duty switch for true 1 Kw POWER – 2 Kw P.E.P.
Ceramic with Coin Silver Switch Contacts



Single Pole, 3 Position.
Desk or wall mount
All unused positions grounded

#CS-3G – UHF connectors / **$36.50***
#CS-3G-BNC – BNC connectors / **$43.95***



Single Pole, 5 Position.
All unused positions grounded

#CS-6G – UHF connectors / **$46.50***
#CS-6G-BNC – BNC connectors / **$59.50***

*Shipping and handling for any item add $2 each.

ALL OUR PRODUCTS MADE IN USA
B·W **BARKER & WILLIAMSON**
Quality Communication Products Since 1932
At your Distributors write or call
10 Canal Street, Bristol PA 19007
(215) 788-5581

COMMANDER II VHF
LINEAR POWER AMPLIFIER



SPECIFICATIONS

Frequency Range – 144-148 MHz
Modes – USB, LSB, RTTY, FM
Power Requirements – 117/234VAC with 234VAC recommended
RF Drive Power – 10-15 Watts Nominal 25 Watts Maximum
RF Output – 15+ DB Gain or over 650 Watts
Input Impedance – 50 OHMS
Output Impedance – 50 OHMS Nominal
Antenna Load – 2:1 Maximum
Harmonic Suppression Down 60DB @ Rated Output
Intermodulation Distortion Down 30 DB Minimum
Weight – 56 lbs.
Cabinet Size – 14¾" x 14¾" x 6"
Tube – 3CX800A7 Ceramic/Metal Triode
Pressurized Chassis Forced Air Cooling

FEATURES

Reduced Ratio (6 to 1) on all Tuning Controls for Smooth and Easy Tuneup.
Front Panel Input Tuning Control Allowing a Higher Circuit "Q" for Excellent Linearity and a Very Low Input VSWR all Across the 2 Meter Band.
A Switched Multimeter for Monitoring Plate Voltage, Plate Current, and Grid Current.
External Coaxial Relay or Sequencer Needed for Transceiver Operation.
UPS Shippable.

MADE IN U.S.A. BY HAMS FOR HAMS
Direct from Manufacturer 179

$988.00 (Coaxial Relay Extra)
Ohio Residents Add Sales Tax VISA and Mastercards accepted Prices or specifications subject to change without notice

COMMAND TECHNOLOGIES, INC.
1117 West High Street, Bryan, Ohio 43506 (419) 636-2721

accommodate signal amplitudes from 2 mv to 200 mv rms.

Some integrated-circuit detector chips include an audio preamp that may supply too much signal for the modem. You can accommodate these larger signals by soldering a resistor (10k to 33k) in parallel with R45.

Use shielded wire between the receiver interface point and the modem. Keep the length as short as possible — avoid a run of more than 10 feet. If you must keep your radio at some distance from your TNC, construct a buffer stage at the detector so that it is not loaded by the capacitance of a long run of shielded cable.

The existing interface for the push-to-talk circuit doesn't need to be changed. Route all signals through the nine-pin connector at the back of the board. You may leave the existing 1200 baud lines on this connector (pins 2 and 4) intact, wiring the new transmit and receive lines to pins 7 and 8. Once you get the new modem running successfully, try switching to 1200 baud using the new tap points in your radio. An adjustment of the 1200 TX level control (P3) should be all that's necessary.

The HAPN card allows two sources of carrier detect — one derived from the demodulator chip (XR2211), the other from an external (squelch-derived) source. A jumper at J1 or J2 selects one of these sources. Jumper J9 selects a third option, the 4800 carrier detect. Because this circuit detects 1200 baud packets, 4800 baud packets, and even voice, remove the jumper on J1 or J2 and install it permanently at J9.

Figure 4B shows an example of the receiver interface to a Kenwood TR-7930 transceiver.

test and alignment

Check the four power supply lines for shorts with an ohmmeter before plugging the modified card back into your computer. After installing the adapter, but before connecting your radio, make sure the dc voltages on all the signal pins of U14 and U15 are 0 volts. Connect your radio and go to a clear channel.

Measure the voltage at TP 1 and adjust potentiometer R44 for about 9 Vdc. This voltage gives the peak amplitude of the audio signal, and should drop to about 6 Vdc during a 4800 baud packet. If R44 adjusts out of range, change R45 up in value if the TP 1 voltage is too low, down in value if it's too high.

Now adjust R74 as you would a squelch control. Use the HAPN "T25" test program to look at the "carrier detect" function. You can also set R74 by looking at U14b pin 7. Adjust for −5 Vdc on a clear channel. It should rise to approximately 0 volts when a carrier is present, or when the radio is disconnected from the modem.

The transmit level control R31 is more difficult to set properly, since you probably have no way of meas-

uring deviation. The 4800 baud deviation should be 3 kHz, a little less than voice deviation of 5 kHz. You might have another station compare the level of your 4800 baud packets with a voice transmission, ideally with a scope. Start R31 off at minimum, increasing it slowly. Setting R31 too high may over-deviate your transmitter and the monitoring station will see only that waveform amplitude is not increasing, although you may be causing adjacent channel interference. Remember that by connecting directly to the modulator you have bypassed the audio limiting circuits; the only thing limiting deviation is R31 in the modem.

The existing factory limiter setting in your radio (which should be close to 5 kHz) can also be used as a reference for setting the 3-kHz deviation for 4800 baud. Hook up your scope at the selected 4800 baud modulating point, apply a signal into the microphone input (use a signal generator or whistle into the mike), and increase the amplitude until you can see limiting on the scope. Note the peak amplitude. This will be your 5-kHz deviation reference. Take 60 percent of this value and use it for adjusting the 4800 baud transmit level (R31). You can also use the same level when adjusting your 1200 baud transmit level (P3).

acknowledgments

This modem is an adaptation of the design by Ken Smith, VE3HWB, so a great deal of credit must go to him. Ken's original article, "Packet Radio with the 1802," was published in the *Ipso Facto* newsletter of the Association of Computer Experimenters (ACE), April 1979. Thanks also to HAPN members VE3IUV, VE3NAV, and VE3MCF for their efforts in building and testing the prototypes, and their contributions to this article.

available from HAPN

The HAPN-1 adapter revision 2 is still available from HAPN as described in the August 1986 article for the same price. Revision 2 contains a number of extra traces in the prototype area to simplify the addition of a second modem there.

We also have a printed circuit board for a stand-alone version of the 4800 baud modem, the HAPN-M, available for $25 U.S. postage paid. The modem is identical to the one described in this article, except that it has RS-232C drivers in the interface to the TNC. It may be used with any RS-232C compatible TNC, or TTL levels if the RS-232C interface circuits are bypassed.

We would like to remind HAPN-1 users who build this modem that a software update may be required to fully support the modem switch. Software updates are $5 U.S. each, plus $5 per diskette. (If you use any of the programs on diskette 2, a diskette 2 update is required along with diskette 1.)

Wiring diagrams of the modem and interfacing diagrams for the Santec ST-144/uP handheld and the ICOM IC-27 transceivers are available from HAPN if you send us a self-addressed envelope and an IRC.

HAPN update

HAPN (Hamilton and Area Packet Network) is a nonprofit association dedicated to furthering the state of packet radio. We are presently working on the TAPR-2 TNC version of the 4800 baud modem and on developing drivers for the VADCG V-3 experimental protocol. We believe that widespread use of 4800 baud will go a long way to improve the efficiency of packet radio local area networks, at minimal cost to the users. The V-3 link level driver is being tested, but the network level is yet to be coded. V-3 is a very interesting networking protocol, an outgrowth of VADCG's V-2 protocol. (For further information on V-3 write VADCG, 9531 Odlin Road, Richmond, BC, V6X 1E1, Canada.)

reference

1. Jack Botner, VE3LNY; Ron Bradshaw, VE3IUV; Max Pizzolato, VE3DNM; John Vanden Berg, VE3DVV; "A Packet Radio TNC for the IBM PC," *ham radio*, August 1986, page 10.

ham radio

KEEP IT INSIDE



- Frequency Range - 13 MHz to 30 MHz
- Power Limit - 1500 Watts P.E.P
- Diameter - 39 inches
- Wind Survival - 70 + MPH
- Surface Area - < .89 Sq. Ft.
- Antenna Finish - Heat Shrink Tubing
- Coax Connector - PL-259
- Antenna Weight - 4 lbs.
- Magnetic Design Maximum Efficiency
- 100% Copper One Piece Construction
- Military Spec Vacuum Variable Capacitor Rated at 35,000 Volts
- HI-Q Harmonic Supression
- All Locations - Indoors or Outdoors
- Bi-Directional at 0-20 Degrees TOA
- Omni-Directional at 25-90 Degrees TOA
- High Signal to Noise Ratio
- Direction Feed 52 OHM Coax SWR < 1.5:1
- No Matching Unit, Pretuned Coax, Ground Screen or Radial System

WA2VMO A BELIEVER

WHEN YOU'RE TULD YOU CAN'T — THE DMQ-5588 SAYS YOU CAN

OPERATION: Apply power to DMQ-5588 and adjust vacuum variable for lowest SWR.

INSTALLATION: DMQ-5588 inside ground floor apartment brick building 100W.

DX CONTACTS MADE BETWEEN 3/88 TO 5/88: 5Z4 P43 PAQ TK9 DJ8 GW0 CP5 YS9 ZS6 J37 ZD8 HP9 WP4 IK4 HK6 GM4 I5 EA5 JH1 C6 HK6 IK2 GD4 PJ2 HP4 CE1 5Z4 5T5 KP4 UT4 SP3 CP3 F9 IK3 N91 UA6, UR2 UP1 YT2 UB5 IV3 EA5 TG9 GJ5 ON7 YU1 VO1 DL6 J73 PY8 TI2 LZ1 PY5 OE4 GI0 G4 WP4 KL7

Become a Believer! For more information about this exciting new antenna, call or write DMQ today! Limited time intro offer: $349.50 + Shipping.

221 Slater Boulevard
Staten Island, NY 10305
(718) 979-3505

180

DMQ TECHNOLOGY

one hundred years of electric waves

A tribute to Heinrich Hertz

One hundred years ago, in a technical high school in Germany, a teacher working with hand-me-down apparatus made a discovery that would affect generations to come. His equipment consisted of little more than a few electrical conductors and a Leyden jar, yet he stumbled upon the basic principle which became the foundation of modern radio, television, radar, and electromagnetic wave communication.

The year was 1886; the man was Heinrich Hertz. Hertz's initial discovery was followed by a series of research studies that firmly established the existence of mysterious and remarkable "electric waves" — waves which could travel through walls and empty space. Today we call them "radio waves," or "electromagnetic radiation."

Most people think that Marconi was the man responsible for radio. Marconi *was* responsible for the practical application of radio, but Hertz laid the groundwork and did all the research work upon which modern radio is based.[1]

Now, 100 years after Hertz's discoveries, it may come as a surprise to many that his work is still the foundation of modern radio. We don't use spark-gap transmitters in our communications today, and Hertz never heard of a superheterodyne receiver — he didn't even see his electrical waves as potential media for communication.[2] But it is amazing to realize the extent to which Hertz's work is represented in hi-tech, high-performance radio communications.

the path to the goal

Hertz's work can be traced to that of such notables as English scientist Michael Faraday and Scottish physicist James Clerk Maxwell. Of particular importance are Faraday's ideas about electrical and magnetic fields, and Maxwell's theoretical predictions of the existence of electromagnetic waves. In 1887, Hertz was working on a problem concerning the relation between electromagnetic forces and the dielectric polarization of insulators. While working with some spiral coils used for demonstrations during his tenure at the Technical High School at Karlsruhe, he noticed that a discharge of a small Leyden jar through one coil caused a spark across a spark gap of the other. Further investigation revealed that there were very rapid electrical oscillations occurring within the coils.

While still pursuing the problem of the dielectric polarization of insulators, Hertz was, as he says: "..frustrated by the invariable occurrence of strong sparking in the secondary conductor..."[3] Now the secondary conductor just happened to be a loop antenna with a spark gap, used as a detector of electromagnetic waves. Of course Hertz had not designed his loop as an antenna; antennas hadn't been invented yet! He designed the loop as the secondary loop of a transformer. At first his results puzzled him. Later in his discussion he says: "It only gradually became clear to me that the law which I had assumed as the basis of my experiment did not apply here..."[3]

Hertz did not realize at first that his electrical oscillations were producing waves which traveled through space. But he was a dedicated researcher and followed where his findings led. He wrote later: "But when I had established with certainty the existence of actual waves, I...arrived at the phenomena which are discribed in the paper 'On Electromagnetic Waves in Air, and their Reflection.'"[3] Hertz realized that he had discovered the electromagnetic waves Maxwell had predicted with his mathematical equations.

By W. Clem Small, KR6A, R 1, Box 64A, Weybridge, Vermont 05753

Hertz: a pioneer among pioneers

You may be surprised to learn that there were others who predated Hertz in demonstrating electric waves in air.* It seems that he was unaware of their work and made his discoveries independently. Let's take a look at these men.

Lord Kelvin, in the preface to the English edition of Hertz's classic *Electric Waves*[3], referred to Joseph Henry who showed that electrical force can diffuse through space in a manner very much like light waves. In 1842, before Hertz's discovery of electric waves, Henry demonstrated such radiation by showing magnetic effects in steel needles caused by lightning bolts miles distant from the needle. The "sparks" of Henry's lightning bolts now seem to be precursors to the sparks of Hertz's spark-coil transmitter.

Then, in 1871, Elihu Thomson and E. A. Houston reported work in which Thomson sent signals between a spark transmitter and a spark-gap receiver (equipment similar to that which Hertz would use) from the basement to the top floor of the school where they taught. In 1876, Sylvanus Thompson used equipment even more similar to Hertz's, to show that another electric wave discoverer, Thomas A. Edison, was wrong in claiming that he had discovered a "new" nonelectric force. Edison had discovered this new force in 1875 while investigating sparking which occurred during work on an electromagnet with a vibrating armature — a device having much in common with the induction coil of Hertz's spark-gap transmitter. Again, the method of detection was the observation of a visible spark at the point of reception. Edison displayed his electric waves only in conductors, not in air. Because of the strange behavior of these waves, he claimed that his new force was not a form of electricity, but of some "etheric" force. Thompson showed that he was wrong, but unfortunately, didn't go on to show just what it was that Edison had discovered. Then in 1880, David Hughes performed studies which demonstrated the effects of Hertz's electric waves. But when Hughes demonstrated his results to emminent scientists of his day, he was discouraged from pursuing the matter. The scientists claimed he was using the well-known principle of induction, rather than displaying something new.

Thomson and Houston, Thompson, Edison, and Hughes all seem to have demonstrated the effects of what were later to become known as radio waves, but none of them pursued the discovery to the same extent as Hertz. Much later, after wireless communication was a reality, Edison sold the patent on his etheric force to Marconi for $30,000.

Perhaps even more startling is the work of E. A. Dolbear, who in 1882 gave the first demonstration of transmission and reception of the human voice with his "electrostatic telephone." Although he did use an induction coil in his transmitter, Dolbear's apparatus differed from Hertz's significantly. Another early wireless pioneer, a dentist named Mahlon Loomis, is often considered a precursor to Hertz for his work with the "aerial telegraph." In 1872, using an aerial and a ground at each site, Loomis used his apparatus to signal for 14 miles between two mountain tops. But his apparatus was also quite different from Hertz's, and Loomis's work is generally thought to have been based on atmospheric conduction rather than electric waves. Some historians believe that Dolbear's work also was not with electrical waves, but by induction — a popular means of early "wireless" communication. Others might deny the inclusion of Henry's or Edison's work in the list of Hertz precursors. Yet other historians would include all those I've mentioned above as legitimatly predating Hertz in the discovery of wireless waves.

It is obvious that a number of men were experimenting with an intent to develop a wireless system using apparatus remarkably like that which Hertz later used to discover electric waves. Yet none of them was able to convince the scientific world that he had indeed found a worthwhile new means of signaling without wires. Before the scientific world would be willing to accept such a claim, Maxwell had to use his mathematics to justify the reasons for believing in such radiation, and Hertz had to provide solid experimental verification of those predictions. Where many had tried, one succeeded.

Hertz's legacy

In the 100 years since the discovery of electromagnetic radiation, there have been tremendous gains in the science and technology of radio communications. We have advanced from the early spark coils and coherers through crystal detectors, arc transmitters, radio-frequency alternators, vacuum tubes, transistors, and on to solid-state devices. Today's technology shows impressive strides beyond Hertz's crude apparatus. But how far have we really come?

Although he didn't foresee the potential his discovery held as a basis for communications, Hertz pioneered the development of some of the most modern communication technology we have today. For instance, the parabolic dish antenna, important to microwave communications, is a direct descendent of Hertz's parabolic reflector antenna. The dipole antenna was also Hertz's discovery and basic to much of his early work. Today dipole antennas are a component

*W. von Bezold, G. F. Fitzgerald, and Oliver Lodge are three other pioneers in the study of electric waves. None of them actually demonstrated electric waves in space, but did precede Hertz with work which had specific implications that could have led to his findings.

of most TV receiving antennas, used extensively in high-frequency work or as the feed antenna in microwave dishes. The world's first loop antenna was the single turn of Hertz's loop with spark-gap receiver. Today, virtually every AM broadcast-band receiver uses a loop antenna. Our contemporary microwave dielectric antenna is a spinoff of his early work on the quasi-optical properties of electric waves as they interact with dielectric materials.

On the other hand, the original Hertzian transmitter, the venerable induction coil with spark gap, has been outlawed since 1938. But I found reference as recently as 1971 to engineering research on the use of electrical spark to generate electromagnetic waves.[4*] The ghost of Henrich Hertz is everywhere!

references

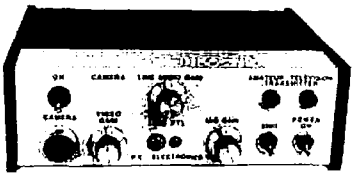
1. Hugo Gernsback, editor, *Jubilee Souvenir Number, Radio Craft*, Radcraft Publications, Inc., Chicago, Illinois, 1938, page 541. Reprinted 1987, New York: Vestal Press.
2. Rollo Appleyard, *Pioneers of Electrical Communication*, MacMillan, London, 1930, page 139-140.
3. Heinrich Hertz, *Electric Waves*, 1893. English language translation by MacMillan and Co., reprinted 1962, Dover Publications, Inc., New York, pages 5 and 11.
4. K. Landecker, L.V. Skatterbol, and D. Growdie, "Single-spark Ring Transmitter," *Proceedings of the IRE*, 1971, volume 59, no. 7, page 1082-1090.

*This happens to be the most recent reference to a spark transmitter I've come across.

AMATEUR TELEVISION

NOVICES: NOW YOU CAN TRANSMIT VIDEO WITH OUR NEW TX23-1

Did you know that you as well as all classes of licensed amateurs can easily transmit live action color and sound video just like broadcast TV with our TX23-1 transmitter. Use any home TV camera and/or VCR, computer, etc. by plugging the composite video and audio into the front 10 pin or rear phono jacks. Call or write now for our complete ATV catalog including downconverters, transceivers, linear amps, and antennas for the 70, 33, & 23cm bands.



Only $299

TX23-1 one watt ATV transmitter crystaled for 1289.25 MHz runs on 12-14 Vdc @ .5A. PTL T/R switching. 7x7x2.5". Transmitters sold only to licensed amateurs for legal purposes verified in the latest Callbook or with copy of license sent with order.

(818) 447-4565 m-f 8am-5:30pm pst.

P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006

Tom (W6ORG)
Maryann (WB6YSS)



the HAM STATION

P.O. Box 6522
220 N. Fulton Ave.
Evansville, IN 47719-0522

Store Hours
MON-FRI: 9AM - 6PM
SAT: 9AM - 3PM
CENTRAL TIME

SEND A SELF ADDRESSED STAMPED ENVELOPE (SASE) FOR NEW AND USED EQUIPMENT SHEETS

WARRANTY SERVICE CENTER FOR: ICOM, YAESU, TEN-TEC

FOR SERVICE INFORMATION CALL (812) 422-0252
MONDAY - FRIDAY
9:00 AM - 12:00 NOON

YAESU



FT-747GX
- 100 Watts of Economical Performance
- Dual VFO's, 20 Memories
- Receives from 100 kHz-30 MHz
- Built-in CW Filter + More



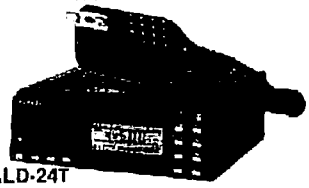
FT-212 RH
- 2 Meter Mobile
- Optional, Internal Digital Voice Recorder
- RX 136-174 MHz
- TX 144-148 MHz
- 45 Watts Output
- FT-712 RH Available for 70cm

ICOM



IC-32AT
- New Dual Band HT
- RX-138-174 MHz 440-450 MHz
- TX-140-150 MHz 440-450 MHz
- 5 Watts Output on Both Bands
- Full Duplex & 40 Memories

ALINCO



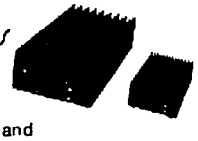
ALD-24T
- Dual Band Mobile 140-149.995 MHz/ 440-450 MHz
- 21 Programmable Memories
- 25 Watts Output on Both Bands
- Loaded with Extra Features

TEN-TEC



PARAGON
- Full Featured Synthesized HF Transceiver
- General Coverage Receiver
- 100w Output
- SSB, CW, FSK, Optional FM
- 62 Programmable Memories
- Made In USA

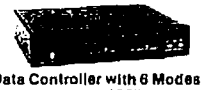
mconcepts



VHF/UHF AMPS
- High VSWR and Overdrive Protection
- 5 Year Warranty, 6 Months on RF Transistors
- All Units have GaAsFET Receive Pre-amps

TERMS:
Prices Do Not Include Shipping.
Price and Availability Subject to Change Without Notice
Most Orders Shipped The Same Day
COD's Welcome

AEA PK-232



Data Controller with 6 Modes

Packet	ASCII
Morse Code	AMTOR
Baudot (RTTY)	Weather Fax

List $319.95 Now Special Priced

SPECIAL

MFJ 989B
3 KW Tuner
$295.



- SWR/Wattmeter
- Antenna Switch
- Built-in Dummy Load

WM.M.NYE

MB-V-A ANTENNA TUNER

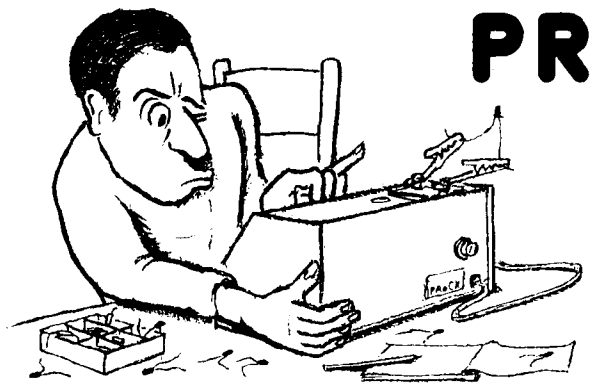


- Push Button Antenna Switching
- 2 Power Meters, 300 and 3,000 Watts
- Tunes 1.8 to 30 MHz

Call Today For Special Price

For Orders and Price Checks Call 800-523-7731

Indiana and Information
Call 1-812-422-0231



PRACTICALLY SPEAKING

Joe Carr, K4IPV

impedance matching

One of the first things an Amateur learns is that the antenna impedance must be matched to the transmission line, and that the transmission line impedance must be matched to the output impedance of the transmitter. This is because maximum power transfer between a source and a load occurs when the system impedances are matched. In other words, more power is transmitted from the system when the load impedance (the antenna), the transmission line impedance, and the transmitter output impedance are all matched with each other.

Of course, the trivial case is where all three sections of our system have the same impedance. For example, you could have an antenna with a simple 75-ohm resistive feedpoint impedance (typical of a half-wave dipole) and a transmitter with an output impedance that will match 75 ohms. In that case, you need only connect a standard impedance 75-ohm piece of coax between the transmitter and the antenna. Job done!

But there are other cases where the job is not so simple. In the case of the standard antenna, for example, the feedpoint impedance is rarely what the books say it should be. That ubiquitous dipole, for example, is nominally rated at 75 ohms but even the simplest antenna book tells us that value is merely the theoretical free-space impedance. At locations closer to the earth's surface that impedance could vary over the approximate range of 30 to 130 ohms and may have a substantial reactive component; so much for standard coaxial cable.

There is a way out of this situation. You can construct a matching system that will marry the source impedance to the load impedance. This month we will examine several matching systems that might prove useful in a number of situations.

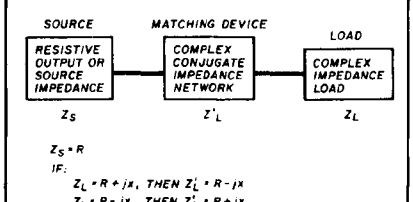


fig. 1. Impedance matching requirement between resistive source impedance and complex load impedance.

impedance-matching approaches

Antenna impedance may contain both reactive and resistive components. In most practical applications you are searching for a purely resistive impedance (Z = R), but that ideal is rarely achieved. A dipole antenna, for example, has a theoretical free-space impedance of 73 ohms at resonance. But as the frequency applied to the dipole is varied away from resonance, a reactive component is added. When the frequency is greater than resonance the antenna tends to look like an inductive reactance, so the impedance is Z = R + jX. Similarly, when the frequency is less than the resonance frequency the antenna looks like a capacitive reactance, so the impedance is Z = R − jX. At distances closer to the earth's surface the resistive component may not be exactly 73 ohms, but may vary from about 30 to 130 ohms. Clearly, whatever impedance coaxial cable is selected to feed the dipole stands a good chance of being wrong.

To match a complex load impedance like an antenna to a resistive source (the most frequently encountered situation in practical radio work), interpose a matching network between the load and the source (**fig. 1**). The matching network must have an impedance that is the complex conjugate of the complex load impedance. For example, if the load impedance is R + jX, the matching network must have an impedance of R − jX; similarly, if the load is R − jX, the matching network must be R + jX. In the sections that follow we'll take a look at some of the more popular networks that accomplish this job.

L-section network

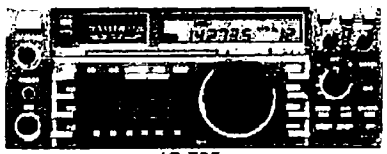
The L-section network is one of the most used, or at least most published, antenna-matching networks in existence. It rivals even the pi-network. A circuit for the L-section network is shown in **fig. 2A**. The two resistors represent the source (R1) and load (R2) impedances. The elementary assumption of this network is that R1 < R2. The design equations are:

$R1 < R2$ *and* $1 < Q < 5$

$X_L = 6.28FL = Q \times R1$

800-882-1343

ICOM



HF Equipment	IC-735	List	JUN's
ICOM			
IC-781 New Deluxe HF Rig		$5995	Call $
IC-761 Loaded with Extras		2699	Call $
IC-735 Gen. Cvg Xcvr		1099	Call $
IC-751A Gen. Cvg Xcvr		1699	Call $
Receivers			
IC-R7000 25-1300* MHz Rcvr		1199	Call $
IC-R71A 100 kHz-30 MHz Rcvr		999	Call $
VHF			
IC-28A/H FM Mobile 25w/45w		469/499	Call $
IC-02AT FM HT		409.95	Call $
IC-2GAT 2m 7w HT		429.95	Call $
IC-900 Six Band Mobile		639	Call $
UHF			
IC-48A FM Mobile 25w		509	Call $
IC-04AT FM HT		449	Call $
IC-4GAT 440MHz HT		429.95	Call $
220 MHz			
IC-38A 25w FM Xcvr		489	Call $
IC 32AT 2m/70cm HT		629.95	Call $

KENWOOD

KENWOOD		
HF Equipment		
TS-940S/AT Gen. Cvg Xcvr	2449.95	Call $
TS-440S/AT Gen. Cvg Xcvr	1379.95	Call $
TS-140S Compact Gen. Cvg Xcvr	929.95	Call $
VHF		
TS-711A All Mode Base 25w	1029.95	Call $
TR-751A All Mode Mobile 25w	649.95	Call $
TM-221A 2m 45w	439.95	Call $
TM-2550A FM Mobile 45w	499.95	Call $
TM-2570A FM Mobile 70w	599.95	Call $
TH-215A 2m HT Has It All	379.95	Call $
TH-25AT 5w Pocket HT NEW	349.95	Call $
TM-721A 2m/70cm FM Mobile	649.95	Call $
UHF		
TM-421A Compact FM 35w	449.95	Call $
TH-45AT 5w Pocket HT NEW	369.95	Call $
220 MHz		
TM-3530A FM 220 MHz 25w	499.95	Call $
TM-321A Compact 25w Mobile	449.95	Call $
TH-315A Full Featured 2.5w HT	399.95	Call $

YAESU

YAESU		
HF Equipment		
FT-767 GX Gen. Cvg Xcvr	1929.95	Call $
FT-757 GX II Gen. Cvg Xcvr	1129.95	Call $
FT-747 GX New Economical Performer	889.95	Call $
FL-7000 15m-160m AMP	1995.00	Call $
VHF		
FT-212RH NEW 2m 45w	459.95	Call $
FT-712RH 70cm 35W	499.95	Call $
FT-290R All Mode Portable	599.95	Call $
FT-23 R/TT Mini HT	344.95	Call $
FT-209RH FM Handheld 5w	389.95	Call $
VHF/UHF Full Duplex		
FT-736R, New All Mode 2m/70cm	1749.95	Call $
Dual Bander		
FT-727R 2m/70cm HT	439.95	Call $
FT-109RH New HT	399.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

$$X_c = \frac{1}{6.28FC} \quad (1)$$

$$Q = \left[\frac{R2}{R1} - 1\right]^{1/2} \quad (2)$$

$$\text{or } Q = \sqrt{\left(\frac{R2}{R1} - 1\right)}$$

also,

$Q = X_L/R1 = R2/X_c$

It's probable that you'll see this network published in conjunction with less than quarter-wavelength long-wire antennas. Those books and articles typically call for a "good ground" for the antenna to work properly. But they don't tell you what a "good ground" is or how you can obtain it. Unfortunately, at most locations a good ground means burying a lot of copper conductor — something that most of us can't afford. In addition, the person who is forced to use a long-wire instead of a better antenna often can't construct a good ground under any circumstances because of landlords and/or logistical problems. The very factors that prompt the use of a long-wire antenna in the first place also prohibit any form of practically obtainable good ground. But there is a way out — radials. A good ground can be simulated with a counterpoise ground constructed of quarter-wavelength radials. These radials have a length in feet equal to $246/F_{MHz}$, and as few as two of them will work wonders. I've used just one radial tacked to the baseboard of a student boarding house room at college and achieved superior results over the poor ground that I'd been able to obtain previously in my third floor abode.

Another form of L-section network is shown in **fig. 2B**. This circuit differs from the previous one in that the roles of the L and C components are reversed. As you might suspect, this switch brings about a reversal of the impedance relationships. In this circuit the assumption is that driving source impedance R1 is larger than load impedance R2 (R1 > R2). The equations are shown below:

$R2 > R1$

$X_L = R2\,[\,R1/(R2 - R1)]^{1/2}$ or

$$X_L = R2 \cdot \sqrt{\frac{R1}{(R2\text{-}R1)}} \quad (3)$$

$X_c = (R1R2)/X_L$

A final form of L-section network is shown in **fig. 2C**. Again, assume that driving source impedance R1 is larger than load impedance R2 (R1 > R2).

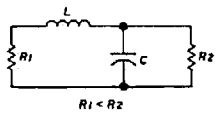


fig. 2A. Classic L-section network.

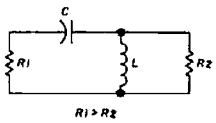


fig. 2B. Reversed L-section network.

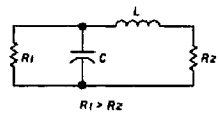


fig. 2C. Inverse L-section network.

In this circuit, the elements are arranged like those in **fig. 2A**, except that the capacitor is at the input rather than the output of the network. The equations governing this network are: $R1 > R2$ and $1 < Q < 5$

$$X_L = 6.28FL = [(R1R2) - (R3)^2]^{1/2} \quad (4)$$

$$\text{or } = \sqrt{(R1R2) - (R3)^2}$$

$$X_c = \frac{1}{6.28FC} = \frac{R1R2}{X_L} \quad (5)$$

$$C = \frac{1}{6.28FX_c} \quad (6)$$

$$L = \frac{X_L}{6.28F} \quad (7)$$

So far, we have considered only matching networks that are based on inductor and capacitor circuits. But there is also a possibility of using transmission line segments as impedance-matching devices. Two basic forms are available: quarter-wave sections and the series matching section.

pi networks

The pi network shown in **fig. 3** is used to match a high source impedance to a low load impedance. These circuits are typically used in vacuum

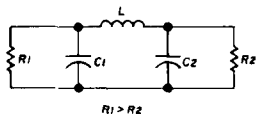


fig. 3. Pi-network.

tube rf power amplifiers that need to match low antenna impedances. The name of the circuit comes from its resemblance to the Greek letter "pi". The equations for the pi network are:

$R1 > R2$ *and* $5 < Q < 15$

$$Q > \left[\frac{R1}{R2} - 1\right]^{1/2} \quad (8)$$

$$\text{or } Q > \sqrt{\frac{R1}{R2} - 1}$$

$$X_{C2} = \frac{R2}{[R2/(R1(1+Q^2) - 1)]^{1/2}} \quad (9)$$

$$\text{or } X_{C2} = \frac{R2}{\sqrt{\frac{R2}{(R1(1+Q^2) - 1)}}}$$

$$X_{C1} = R1/Q$$

$$X_L = \frac{(R1\ (Q + (R2/X_{C2})))}{Q^2 + 1} \quad (10)$$

split-capacitor network

The split-capacitor network shown in **fig. 4** is used to transform a source impedance that is less than the load impedance. In addition to matching

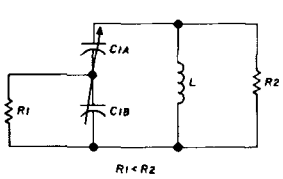


fig. 4. Split-capacitor network.

antennas, this circuit is also used for interstage impedance matching inside communications equipment. The equations for design are:

$R1 < R2$

$$Q > \left[\frac{R2}{R1} - 1\right]^{1/2} \quad (11)$$

$$\text{or } Q > \sqrt{\left(\frac{R2}{R1} - 1\right)}$$

$$X_L = R2/Q$$

$$X_{C1B} = \left[\frac{R1\ (Q^2 + 1)}{R2} - 1\right]^{1/2} \quad (12)$$

$$\text{or } X_{C1B} = \sqrt{\left(\frac{R1(Q^2 + 1)}{R2} - 1\right)}$$

$$X_{C1A} = \frac{R2\ Q}{Q^2 + 1} \quad (13)$$

$$\left[1 - \frac{R1}{Q\ X_{C1A}}\right]$$

transmatch circuit

One version of the transmatch is shown in **fig. 5**. This circuit is basically a combination of the split-capacitor network and an output tuning capacitor (C2). For the hf bands, the capacitors are on the order of 150 pF per section for C1, and 250 pF for C2. The roller inductor should be 28 μH. The transmatch is essentially a coax-to-coax impedance matcher, and is used to trim the mismatch from a line before it affects the transmitter.

Perhaps the most common form of transmatch circuit is the T-network shown in **fig. 6**. This network costs less than some of the others, but has a problem. While it does match impedance (and thereby "tune out" VSWR on coaxial lines), it also has a high-pass characteristic so does not reduce the harmonic output of the transmitter. The T-network, therefore, does not serve one of the main purposes of the antenna tuner — harmonic reduction. An alternative network, called the SPC transmatch, is shown in **fig. 7**. This version of the circuit offers harmonic

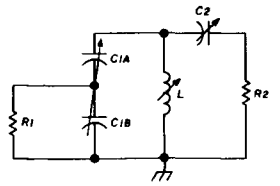


fig. 5. Transmatch variant circuit.

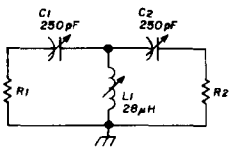


fig. 6. T-network transmatch circuit. This circuit has a substantial high-pass characteristic so it will not suppress harmonics.

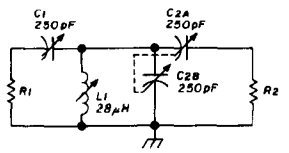


fig. 7. ReVised T-network, the SPC transmatch, suppresses harmonics.

attenuation as well as matching impedance.

coaxial cable baluns

A balun is a transformer that matches a BALanced load (like a dipole antenna) and an UNbalanced resistive source impedance (like a coaxial cable). With the circuit in **fig. 8** you can make a balun that will transform impedance at a **4:1** ratio, with R2 = **4** × R1. The length of the balun section coaxial cable is:

$$L_{ft} = \frac{492\ V}{F_{MHz}} \quad (14)$$

Where:

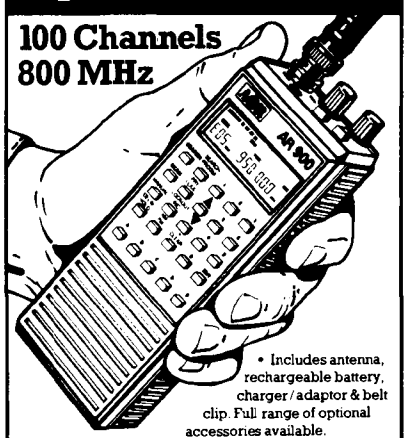
L_{ft} is the length in feet

V is the velocity factor of the coaxial cable

F_{MHz} is the operating frequency in megahertz

New Scanner by AOR

100 Channels 800 MHz



- Includes antenna, rechargeable battery, charger/adaptor & belt clip. Full range of optional accessories available.
- Covers 27-54 MHz, 108-174 MHz, 406-512 MHz, and 800-950 MHz.
- 5 Scan Banks and 5 Search Banks.
- 25 Day Satisfaction Guarantee, Full Refund if not Satisfied.
- No Frequencies cut out.
- Size: 2" x 5¾" x 1½" wt: 12 oz.

AR900
Total Price, Freight Prepaid (Express Shipping Optional)
$299.00

COMMUNICATIONS
10707 E. 106th St. Indpls., IN 46256
Toll Free **800-445-7717**
Visa and MasterCard (COD slightly higher)
In Indiana 317-849-2570 Collect FAX (317) 849-8794

169

CIE Cleveland Institute of Electronics
1776 East 17th St., Cleveland, Ohio 44114

170

Accredited Member National Home Study Council

CIE is the world's largest independent study electronics school. We offer ten courses covering basic electronics to advanced digital and microprocessor technology. An Associate in Applied Science in Electronics Engineering Technology is also offered.

Study at home — no classes. Programs accredited and eligible for VA benefits.

CIE Cleveland Institute of Electronics
1776 East 17th St., Cleveland, Ohio 44114
YES! I want to get started. Send me my CIE school catalog including details about the Associate Degree program.

Print Name _____
Address _____ Apt. _____
City _____ State _____ Zip _____
Age _____ Area Code/Phone No. _____
Check box for G.I. Bulletin on Educational Benefits
☐ Veteran ☐ Active Duty MAIL TODAY!

AHR-04

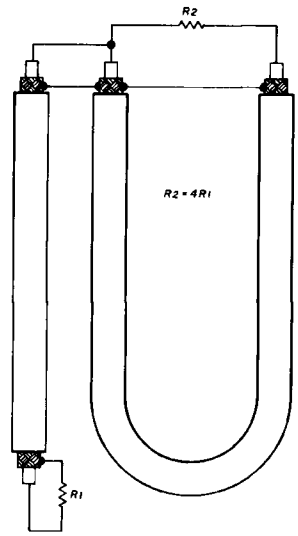


fig. 8. Coaxial cable 4:1 balun transformer.

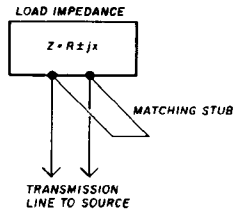


fig. 9A. Basic configuration for stub matching.

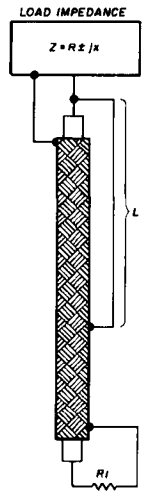


fig. 9B. Coaxial matching section.

matching stubs

You can build a shorted stub to produce almost any value of reactance. Use this information to make an impedance-matching device that cancels the reactive portion of a complex impedance. If you have an impedance of, say, Z = R + j30 ohms you need to make a stub with a reactance of −j30 ohms to match it. Two forms of matching stub are shown in **figs. 9A** and **9B**. These stubs are connected exactly at the feedpoint of the complex load impedance, although they are sometimes placed further back on the line at a (perhaps) more convenient point. In that case, the reactance required will be transformed by the transmission line between the load and the stub.

quarter-wave matching sections

Figure 10 shows the elementary quarter-wavelength transformer section connected between the transmission line and the antenna load. This transformer is also sometimes called a Q-section. When things are designed correctly, this transmision line transformer is capable of matching the normal feedline impedance (Z_S) to the antenna feedpoint impedance (Z_R). You must have a piece of transmission line available that has an impedance Z_o of:

$$Z_o = (Z_S Z_R)1/2 \text{ or } \quad Z_o = \sqrt{(Z_S Z_R)} \qquad \textbf{(15)}$$

Most texts show this circuit for use with coaxial cable. While it is certainly possible, and even practical in some cases, for the most part there is a serious flaw in using coax for this project. It seems that the normal range of antenna feedpoint impedances, coupled with the rigidly fixed values of coaxial cable surge impedance available on the market, combine to yield unavailable values of Z_o. While there are certainly situations that yield to this requirement, many times the quarter-wave section is not usable on coaxial cable antenna systems using standard impedance values.

On parallel transmission line systems, however, it is quite easy to achieve the correct impedance for the matching section. Use the equation above to find a value for Z_o, and then

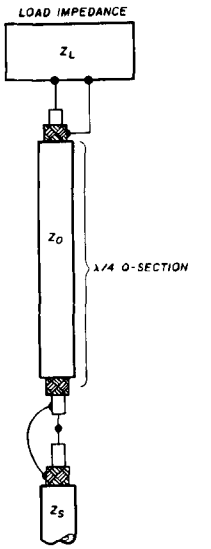


fig. 10. Quarter-wave Q-section matching.

calculate the dimensions of the parallel feeders. Because you know the impedance, and can more often than not select the conductor diameter from available wire supplies, use the equation below to calculate conductor spacing:

$S = D10^{(Z/276)}$

Where:

S is the spacing, D is the conductor diameter (D and S in the same units), and Z is the desired surge impedance. From there you can calculate the length of the quarter-wave section from the familiar $246/F_{MHz}$.

series matching section

The quarter-wavelength section discussed above has several drawbacks: it must be located at the antenna feedpoint, it must be quarter wavelength, and it must use a specified (often nonstandard) value of impedance. The series matching section is a generalized case of the same idea, and permits you to build an impedance transformer that overcomes most of these faults. According to *The ARRL Antenna Book*, this form of transformer is capable of matching any load resistance between about 5 and 1200 ohms. In addition, the transformer section is not located at the antenna feedpoint.

Figure 11 shows the basic form of the series matching section. There are three lengths of coaxial cable: L1, L2,

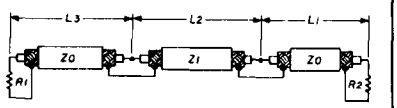


fig. 11. Coaxial matching transformer.

and the line to the transmitter. Length L1 and the line to the transmitter (which is any convenient length) have the same characteristic impedance, usually 75 ohms. Section L2 has a different impedance from L1 and the line to the transmitter, usually 75 ohms. Note that only standard, easily obtainable values of impedance are used here.

The design of this transformer involves finding the correct lengths for L1 and L2. You must know the characteristic impedance of the two lines (50 and 75 ohms given as examples) and the complex antenna impedance. In the case where the antenna is nonresonant, this impedance is of the form $Z = R \pm jX$, where R is the resistive portion, X is the reactive portion (inductive or capacitive) and j is the so-called "imaginary" operator, i.e., square root of -1. If the antenna is resonant, then $X = 0$, and the impedance is simply R.

The first chore in designing the transformer is to normalize the impedances:

$N = Z_{L1}/Z_o$
$R = R_L/Z_o$
$X = X_L/Z_o$

The lengths are determined in electrical degrees, and from that determination you can find length in feet or meters. If you adopt ARRL notation and define A = TAN (L1), and B = TAN (L2), then the following equations can be written:

If: $Z_L = R_L \pm jX_L$

$$TAN\ L2 = B = \pm\sqrt{\frac{(r-1)^2 + X^2}{r(N - (1/N)^2 - (r-1)^2 - X^2}} \quad (16)$$

$$TAN\ L1 = A = \frac{(N - (r/N)) \times B + X}{R + (XNB) - 1} \quad (17)$$

Where:

$N = Z1/Z_o$
$r = R_L/Z_o$
$Z = X_L/Z_o$

Constraints:

$Z1 > Z_o\ [VSWR]^{1/2}$
or, $Z1 < Z_o/[VSWR]^{1/2}$
If $L1 < 0$, then add 180 degrees
If $B < 0$, then Z1 is too close to Z_o
Z1 not equal to Z_o
$Z_o[VSWR]^{1/2} < Z1 < Z_o/[VSWR]^{1/2}$

Physical length in feet:

$L1' = L1\ \lambda/360$
$L2' = L2\ \lambda/360$

Where:

$$\lambda = \frac{984 \times Velocity\ Factor}{Frequency\ in\ Megahertz} \quad (18)$$

The physical length is determined from ARCTAN (A) and ARCTAN (B), divided by 360, and multiplied by the wavelength along the line and the velocity factor.

Although the sign of B may be selected as either + or −, the use of + is preferred because a shorter section is obtained. In the event that the sign of A turns out negative, add 180 degrees to the result.

There are constraints on the design of this transformer. For one thing, the impedances of the two sections L1 and L2 can't be too close together. In general, the following must obtain:

Either,
$Z_{L1} > Z_o \times SWR$
or, $Z_{L1} < Z_o/SWR$

Analysis of
multi-element arrays;
all-driven-element design

the Quad antenna part 3,
circular-loop and octagonal arrays

An array of two or more circular loops (like any other antenna) can have all elements driven, or some driven and the others self-excited, or parasitic. The special case of one driven element is sometimes called the Yagi-Uda configuration; this really applies only to the configuration of one parasitic reflector, a driven element, and one or more parasitic directors, all elements being dipoles.

Part 3 addresses circular-loop and octagonal arrays — initially with two elements, then with more. This is followed by a limited discussion of a particular all-driven-element design.

theory of two circular-loop arrays

The relationships between two circular loops, parallel and on a common axis, are shown in **fig. 1**. Compare this with the single-loop drawing in part 2, **fig. 1**. The important difference is that two loops contribute to the field, and in turn, to the induced currents. They have the same requirement that the component of the field along the wire be zero.

Computational complexity can be reduced if the current on each loop is assumed to be the sum of two currents, of the form:

I1 = Ia + Ib

I2 = Ia − Ib

Those with power-line engineering training will recognize this as a form of "symmetrical component" analysis used for multiphase power lines.

The assumed currents Ia and Ib are the same on both loops. This allows you to solve for the currents using Hallen's[2] method. Unfortunately, this simplification does not help much in practical calculation.

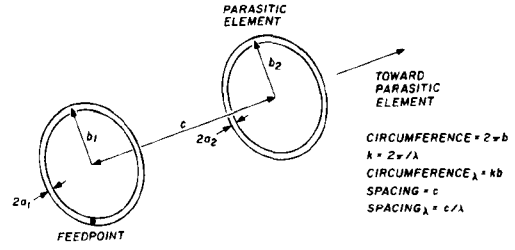


fig. 1. Geometry and nomenclature for a circular loop array. Two quantities are needed to describe each element, and another to specify the spacing, the letter C is used here. For octagons, an added descriptor for the number of sides is needed.

There is no easy way to use the ten curves prepared by Storer[1,3] to derive the currents on the two elements. Theory application is beyond practical small computer use; a large computer is needed. But a number of published results of this theoretical analysis can be applied to practical antennas. These will serve as the basis for some further analyses, for comparison, and also provide some data on the performance of practical designs.

the basic two-loop array

As with the Yagi, the two-loop array with one loop parasitically excited is both a useful antenna and the basis for further array expansion. Practically, these

By R.P. Haviland, W4MB, 1035 Green Acres Circle North, Daytona Beach, Florida 32019

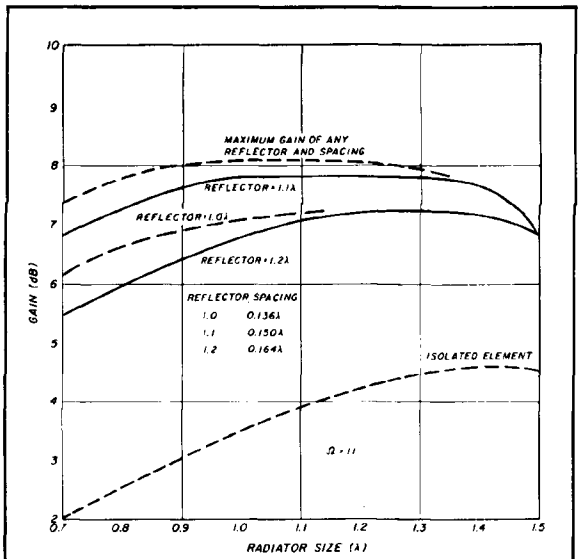


fig. 2. Forward-lobe gain for a reflector-radiator combination, plotted against size of radiator. Separate curves are shown for reflectors of 1.0, 1.1 and 1.2 wavelengths circumference. The top curve shows the maximum gain possible by choice of reflector size and spacing. Gain of an isolated element is shown for comparison. Data from Ito et al.[11]

two-element arrays give the largest increase in performance for a given investment in size and weight.

All the performance data on the designs described here are derived from Ito, Inagaki, and Sekiguchi[11]. Gain values are in dB above isotropic, unless otherwise noted.

gain performance

Figure 2 shows the forward gain performance with the parasitic element tuned as a reflector. The top curve shows the maximum gain with retuning; the nearly parallel curves show the gain for a specific parasitic element size.

For the two-element beam with reflector, the maximum gain is 8.1 dB. The gain is <3 to >5 dB higher than the gain of an isolated radiator of the same size. Over the range of radiator size from 1.0 to 1.25 wavelengths, the optimum gain varies only by 0.1 dB or so. Also, the gain does not vary greatly for changes in reflector size, typically by ± 0.6 dB for a change from 1.1 to 1.3 wavelengths loop size. This means that the two-element loop with reflector is a good wideband antenna, with nearly constant forward gain over the wide frequency range of ± 15 percent.

Forward gain performance with the parasitic element tuned as a director is shown in **fig. 3**. The top curve shows the maximum gain that can be developed for a given radiating loop size by tuning the director and choosing the best spacing. The nearly parallel curves give the gain for given sizes of the director. Also shown is the gain of a single isolated element.

The maximum two-element gain is 7.3 dB. This represents almost exactly a 3-dB increase over a single loop of the same size. This 3-dB increase is essentially independent of radiator size but is sensitive to director dimension.

The combination of nearly maximum gain and good gain stability led the developers of this data to recommend that the radiator loop be larger than resonant size. Their specific recommendation is 1.2 wavelengths circumference. Some consequences of this are discussed later.

The curves for a 1.2-wavelengths radiator in **figs. 4** and **5** are also useful. The variable for these curves is radiator-parasitic spacing in wavelengths.

As we have seen, maximum gain with the parasitic element as a reflector is 8.1 dB, and for the parasitic element as director it is 7.3 dB. These values show on the curves. Maximum reflector gain occurs at 1.08 wavelengths loop circumference at a spacing of 0.15 wavelength. Maximum director gain occurs at 0.95 loop circumference and a spacing of 0.1 wavelength.

Minimum back radiation with a reflector is -12.1 dB. This nearly occurs over the range of reflector sizes from 1.1 to 1.15 wavelengths circumference, and the range of spacing from 0.1 to 0.25 wavelength. Maximum front-to-back ratio occurs at a circumference of 1.1 wavelengths and a spacing around 0.1 wavelength. It is about 20 dB.

The data in part 1 shows that the optimum director size for minimum back radiation varies markedly with spacing. Minimum back radiation with the parasitic as a director is -3 dB, but this occurs for spacings around 0.6 wavelength, beyond the range of practical use. The forward gain is only 2 dB at this point. The practical minimum backlobe level is essentially 3 dB, occurring over the range 0.8-0.96 wavelength director circumference and a spacing of 0.1 wavelength. The front-to-back ratio is only 4 dB. A director of 0.9 wavelength circumference and 0.15 wavelength spacing will give nearly as good gain and front-to-back ratio.

These data show that the best design values for a two-element circular loop array, and for the radiator-reflector combination for larger arrays, are the same. Maximum performance is obtained from

- Radiator circumference, 1.2 wavelengths.
- Reflector circumference, 1.1 wavelengths.
- Element spacing, 0.15 wavelength.

Radiator circumferences from 1.1 to 1.3 wavelengths give nearly the same performance.

drive impedance

The drive impedance of an isolated loop is a complex

function of loop and conductor diameter. These factors apply with a parasitic element present plus the added complexity of the changes introduced by the currents on that element. Because of this there is very little data on feed impedances in scientific or engineering literature. It is necessary to use the limited amount available to develop trends and then depend on measurements to design the antenna feed. Fortunately this is not difficult, given the wideband characteristics of loop antennas.

The paper by Ito, et al.[11] includes a single set of curves that give useful information about the radiator-reflector combination. Data is for a reflector of 1.1 wavelengths circumference, with an element omega of 11, corresponding to a loop-to-conductor radius of 39. This is typical of a self-supporting UHF antenna.

The following values are developed from the curves; resonance, of course, means that the drive reactance is zero:

- Isolated resonant loop
  Radiator circumference = 1.1 wavelengths.
  Drive resistance = 153 ohms.
- Resonant radiator with reflector
  Radiator circumference = 1.08 wavelengths.
  Drive resistance = 139 ohms.
- Resonant radiator with director
  Radiator circumference = 0.87 wavelength.
  Drive resistance = 250 ohms.
- Isolated 1.2-wavelengths loop
  Drive resistance = 215 ohms.
  Drive reactance = 84 ohms.
- 1.2-wavelengths radiator with reflector
  Drive resistance = 158 ohms.
  Drive reactance = 365 ohms.
- 1.2-wavelengths radiator with director
  Drive resistance = 33.5 ohms.
  Drive reactance = − 132 ohms.

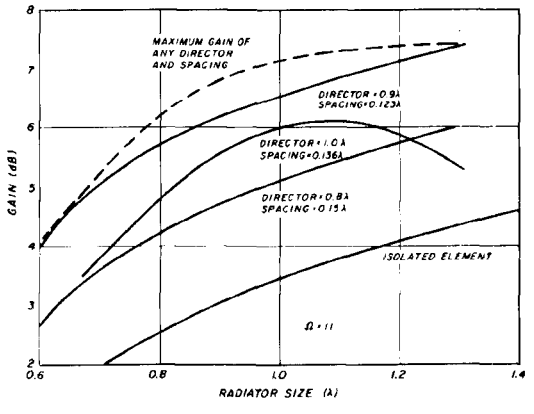


fig. 3. Forward-lobe gain for a director-radiator combination, plotted against radiator size. Separate curves are shown for directors 0.8, 0.9 and 1.0 wavelengths circumference. The top curve shows the maximum gain possible by choice of director size and spacing. Gain of an isolated element is shown for comparison. Data from Ito et al.[11]

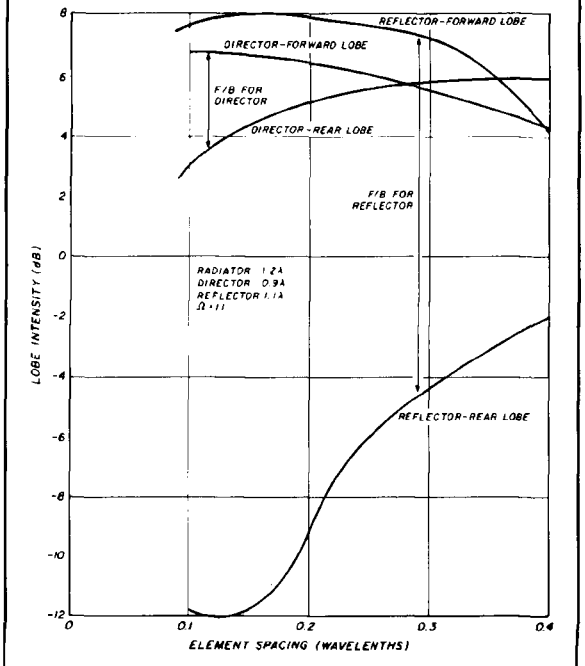


fig. 4. Forward and back lobe intensities for typical radiator-parasitic combinations, plotted against parasitic spacing. As usual for parasitic elements, maximum gain and maximum front-to-back ratio occur for different conditions. For two-element antennas, the reflector at 0.12 wavelength spacing is a good choice. Data from Ito et al.[11]

The change in impedance is greater for the director and this behavior is much the same as for the two-element Yagi. The reason for the increase in drive resistance for the resonant element with director lies partly in the marked change in length needed to cancel the self- and induced reactances.

Remember that a standard method of matching is to change the length of the driven element, then add a stub to cancel the reactance, leaving the resistance at the value that matches the line impedance. You can also do this with loops, but it may require some loss in loop area and therefore loop gain. A gamma match, or stub-transformer sections, would be a better choice.

For most two-element arrays, a good feed is a 4:1 balun at the antenna, used with 50-ohm line. Solid-state transmitters will probably require a better match to obtain rated output, say by use of a transmatch. A possibility is a gamma match, used by at least one commercial design with good results. The simplest alternative is to use low-loss line, say 75-ohm Teflon™

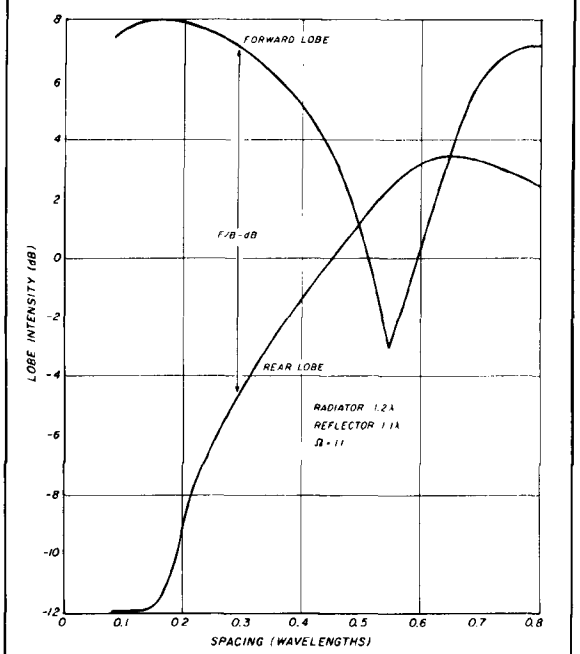


fig. 5. Forward and back-lobe intensities for a reflector-radiator combination over a wide range of spacings. With no change in element size, relative lobe intensities reverse around 0.6 wavelength spacing. Wider spacings can give fair forward lobe performance, but the back lobe remains large. Data from Ito et al.[11]

or foam, or 300-ohm twin lead, plus an appropriate transmatch. A transmatch is a necessity if you want the full advantage of the wideband loop characteristic.

patterns

There is a limited amount of theoretically derived pattern data in current literature. **Figure 6A-C** is replotted from the patterns in Ito et al.[11] which are similar to the corresponding patterns of two-element Yagi antennas[16]. The front-to-back ratio is reasonably good for reflectors in the 1.1-1.2 wavelengths circumference range. Directors of any size give poor front to back, although the forward gain is good, as described above.

None of the theoretical analyses found in the literature show patterns in other planes or for cross-polarization. These will be covered later by approximate analysis.

multi-element arrays

The theory above for two-element antennas has been used to examine the properties of multi-element circular-loop arrays, by Ito et al.[11] and by Shoamanesh and Shafai.[17,18] Experimental work has been reported by Appel-Hansen.[13] Their work is summarized in **figs. 7** and **8** and shows the gain versus array length. Also shown is the theoretical gain of Yagi antennas derived by Lawson.[19]

The gain for the usual Yagi is determined primarily by array length. The first few directors add about 1 dB per director. Thereafter, the gain increases about 3 dB for each doubling of array length.

Information in **table 1** is taken from Shoamanesh and Shafai's[17] theoretical table. All of the entries are for a director spacing of 0.3 wavelength. This gives maximum gain for the number of elements used, and reasonable front-to-back performance. Gain, expected drive impedance, and minor lobe characteristics plus front-to-back ratio are tabulated.

Arrays constructed from the table values should be

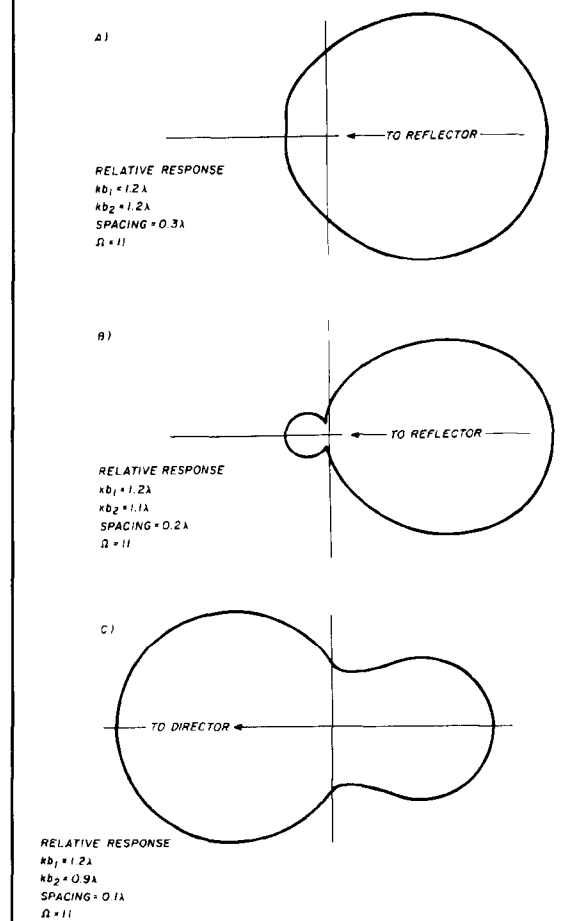


fig. 6. Horizontal plane patterns with horizontal polarization for three selected radiator-parasitic combinations. A and B show patterns with reflectors; C shows a pattern using a director. The front-to-back ratio of a reflector is good for a fairly wide range of conditions. While the director forward gain is also good over a fairly wide range, the front-to-back ratio is always poor. Patterns are scaled from a number plotted by Ito et al.[11]

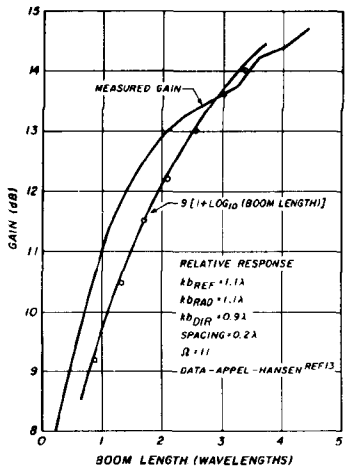


fig. 7. Measured gain of multi-element circular loop arrays, plotted against total boom length. Gain shown is not necessarily the maximum for the boom length given. The arbitrary curve is shown for comparison. Data from Appel-Hansen.[13] See also Lindsay.[12]

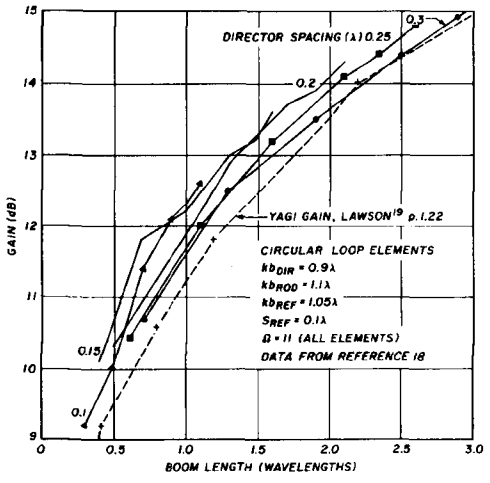


fig. 8. Calculated gain of multi-element circular loop arrays, plotted against boom length. Separate curves are shown for director spacings of 0.1, 0.15, 0.2, 0.25, and 0.3 wavelength spacing. For most boom lengths, a small increase in gain can be attained by using close spacing. There are penalities for this: for example, greater wind load, and usually, smaller bandwidth. Data from Shoamanesh and Shafai.[18]

easy to build in self-supporting form for frequencies in the VHF, UHF, and SHF ranges. By adopting the principle of the bicycle wheel, discussed in a later part of this series, you can build hf designs.

The design values in **table 1** are known to be near optimum for maximum performance. A small increase in gain may be obtained by making some changes in element size and spacing. Unfortunately, there may be appreciable change in minor lobe structure if much retuning is attempted.

The only theoretical data relating to the gain of multi-element circular-loop arrays comes from the same source,[17,18] and is summarized in **fig. 8**. This again shows gain versus boom length, but with individual curves for director spacing. A small but definite increase in gain is usually possible by adding directors, but the limit of improvement is not known. Retuning must be done carefully. Front-to-back ratios vary from about 10 to over 25 dB from one set of spacings to another, and there are probably changes in bandwidth as spacing changes. Shoamanesh and Shafai[17] give some guidelines for design optimization.

The data in Chapers 2 and 3 of Lawson[19] gives more information on results obtainable by optimization. Conversion of this data to loop design conditions is somewhat tedious. First calculate the self- and mutual reactances for the length and spacing data given by Lawson.[19] Then transform these values to loop size and spacing, using the curves and tables given in this series or the references. The basic computational proc-

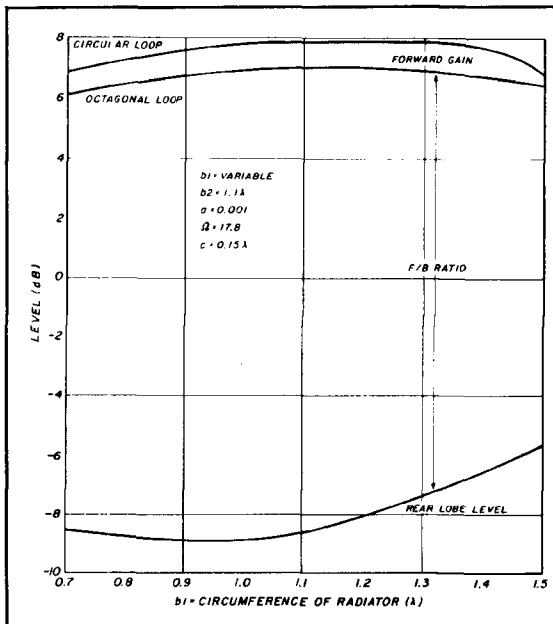


fig. 9. Calculated front and back lobe levels of an octagonal array, plotted against radiator circumference. Radiator circumference is 1.2 and spacing is 0.15 wavelength. The gain of a two-element circular loop is shown for comparison. The variation in gain would be more marked if the size of the reflector were also varied, but this shows again that loop antennas are broadband. The difference in circular and octagonal gain appears to be largely due to calculation technique differences.

Table 1. Calculated performance of multi- and circular-loop arrays.

no. directors	boom wavelengths	gain (dB)	F/B (dB)	H-B/W (Deg)	E-B/W (Deg)	drive:R (Ohms)	drive:jx (Ohms)
2	.70	10.70	15.20	59.00	54.00	58.50	156.70
4	1.30	12.50	25.80	48.00	44.50	44.20	168.00
6	1.90	13.50	14.20	40.50	38.50	56.00	179.80
8	2.50	14.40	14.20	35.00	32.50	63.60	163.30
9	2.80	14.80	16.40	32.50	30.50	52.00	17.50
10	3.10	15.20	23.00	30.50	30.00	45.60	163.10

Reflector = 1.1, radiator = 1.2, and all directors = 0.9 wavelength circumference. Reflector is spaced 0.15 and directors 0.3 wavelength. The nine-director array needs no matching, the others only a capacitive stub across the feedpoint. A balun is not necessary, but is probably helpful in avoiding feedline and tower radiation.

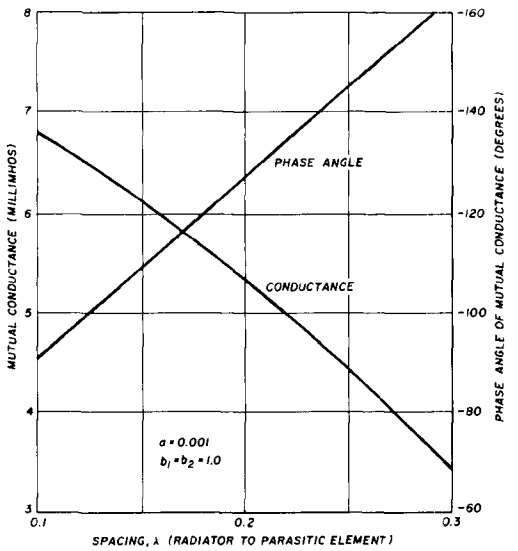


fig. 10. Mutual admittance of two octagonal loops, one wavelength in diameter. For wider separation, the magnitude of the admittance decreases nearly inversely with separation, and the phase linearly. These curves plus the self admittance data given in the second article of the series allow determination of array patterns by use of pattern multiplication techniques.

ess described in Lawson's Chapter 1[19] or in Kraus[20] can be modified for loop anaylsis.

octagonal arrays and loop approximations

Arrays of polygons are not common; circular elements are usually just as easy to build. There is also the matter of added resistance at the joints between segments, if present. The octagonal array data included here is primarily for use in approximating the performance of circular-loop arrays.

Figure 9 is for comparison and gives the gain and front-to-back ratio for a two-element octagonal array. It is very nearly the same as for the two-element circular array of **fig. 2.**

Figure 10 gives the mutual admittances between two 1.0-wavelength elements. Combined with the self-admittance values of **table 1**, these curves allow calculation of the currents in any multi-element array, and in turn the pattern as described by Kraus[20] and used by Lawson.[19] As mentioned above, these curves make the performance data calculated by Lawson[19] useful as an approximation to circular-loop (and other shape) arrays.

patterns of octagonal arrays

Figure 11 shows the MININEC-calculated horizontal-plane pattern of a two-element, bottom-fed array with a parasitic director — an array with nominally horizontal polarization. Radiator and director circumferences are 1.0 and 0.9 wavelengths, and spacing is 0.15 wavelength. The pattern resembles that of an equivalent two-element Yagi, which also shows poor front-to-back ratio. Somewhat more gain could be obtained with a larger radiator and closer spacing.

Figure 12 shows the same calculation for a 1.1-wavelengths reflector. Gain is nearly maximum from this element combination, and the back lobe is reasonably small. This appears to be a good choice for a two-element beam or for the exciter section of a large array.

Figure 13 shows the same calculation for a three-element octagonal array, with 0.9, 1.2, and 1.1 director, radiator and reflector circumferences, with the director spaced at 0.2 and the reflector at 0.15 wavelength. The gain is close to but below the maximum attainable with this boom length. The front-to-back ratio is reasonable. Experience with 2, 10, 15 and 20-meter versions of this combination indicates that better front to back, up to about 30 dB, is possible

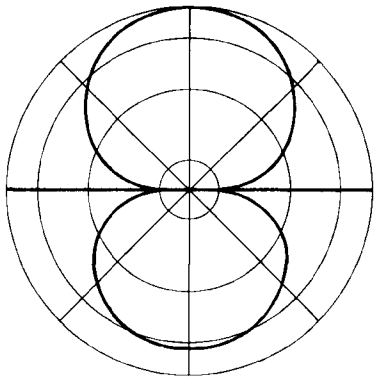


fig. 11. Horizontal plane pattern of the h-polarized component from a bottom-fed director-radiator combination. Circumferences are 0.9 and 1.0 wavelength. Spacing is 0.15 wavelength. Forward gain is reasonable, but the back lobe is large.

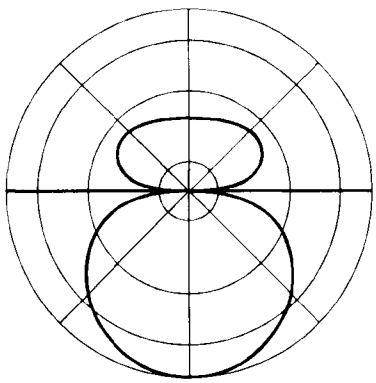


fig. 12. Horizontal plane pattern of a 1.1 wavelength reflector-radiator combination. Other conditions same as in fig. 11. Forward gain is excellent for a two-element antenna. The front-to-back ratio of about 13 dB is good.

with element tuning. **Figure 8** shows that the gain could be increased about 1 dB by a second director at 0.1-wavelength spacing.

Figure 14 shows another pattern for the same beam for the total radiation component. Because of the small cross-polarized component present in loops, the sides of the pattern are filled in, so the front-to-side ratio is poor.

It is my experience that the filled-in pattern is correct for high-angle or E-layer radiation. However, low-angle radiation, typical of F2-layer DX, shows the high front-to-side discrimination of **fig. 13.** Under good conditions, an S9+ signal can be dropped to the noise level if the signal is placed on the 90-degree null. This results in a reduction of 40 dB or more. The same characteristic is noted on 15 meters when E-layer skip is present. Published theoretical analyses shed no light on this performance difference. It appears to be associated with ground reflection. We will return to this subject later in this series.

all-driven arrays

As with dipole elements, loops can be used in driven arrays. Driven arrays are not common in Amateur use because of space requirements. The few occasionally encountered are typically two-element designs. These are also used in place of a single radiator element in some high-performance arrays, partly for gain and front-to-back improvement, but also to improve the effective bandwidth.

Figure 15 shows the MININEC-calculated gain for two 1.0-wavelength loops spaced 0.12 wavelength,

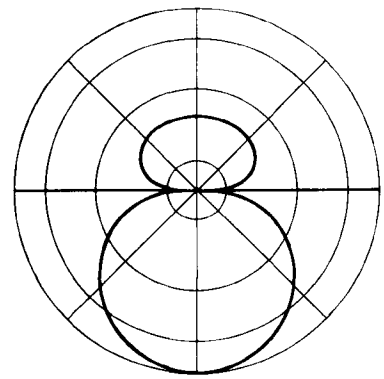


fig. 13. Horizontal plane pattern of a bottom-fed, three-element octagonal array. Circumferences are director = 0.9, radiator = 1.2 and reflector = 1.1 wavelengths. Director spacing is 0.2 and reflector 0.15 wavelength.

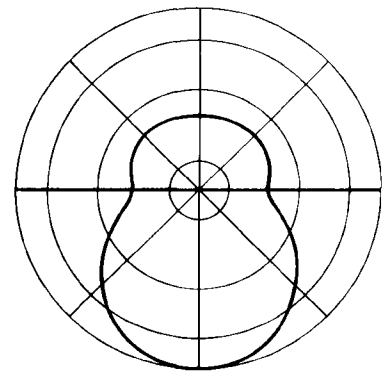


fig. 14. Total component radiation pattern for the array of fig. 13. The vertical component fills in the side-lobe area. See text for practical experience with an antenna of this type.

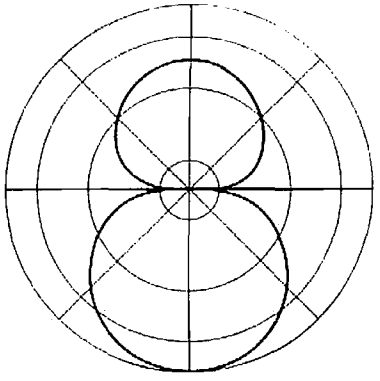


fig. 15. Horizontal component pattern for two one-wavelength loops separated 0.12 wavelength and bottom fed 135 degrees out of phase. The antenna is related to the "ZL-Special", and is useful by itself. The technique is also useful as the feed of large arrays, to give better front-to-back and gain.

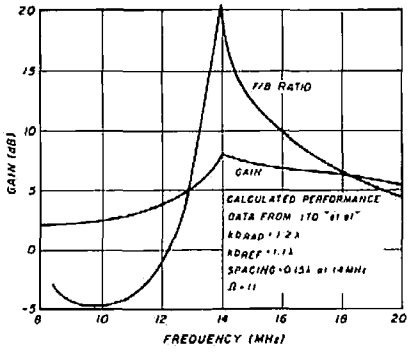


fig. 16. Calculated gain and front-to-back ratio of a two-element array designed for 14 MHz, but operated over the range 8-22 MHz. Forward lobe gain exceeds that of a dipole over the entire range. The back lobe can even be larger than the main lobe, but effective interference reduction is usually possible by rotating the antenna to place the interference in a null. Any antenna of the Quad family is a useful wide-band antenna for occasional operation on other than designated bands. Based on data from Ito et al.[11]

and fed 135 degrees out of phase, like the "ZL-Special" antenna. The gain performance is good, but the back lobe is rather large. Antennas of this type will be studied further when we discuss rectangular loops.

super-wideband operation

Figure 16 shows the calculated performance of a 20-meter two-element array from 8.5 to 20 MHz. The gain curve shows that this parameter exceeds that of a dipole over the entire range. In fact, the performance is reasonable over 7 to 30 MHz, although there is lobe splitting on the higher bands, and main-lobe reversal on the lower ones. Front-to-back ratio is high only near the design frequency, however.

The secret of using this wide bandwidth lies in the transmission-line matching technique used. I prefer Teflon-insulated 75-ohm cable. Open-wire line or twin lead is also good. A matchbox is a necessity. (I think that a matchbox should always be used to simplify using the entire band and to reduce harmonic radiation.) One fact seems clear: if you are using a Quad, you can have multiband operation without a lot of real estate for an antenna farm.

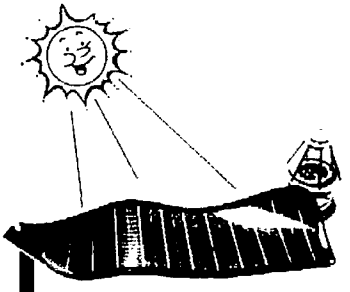
Part 4 deals with the square or Quad loop and some of its close relatives.

references

16. F.E. Terman, *Radio Engineers' Handbook*, McGraw-Hill, New York, 1943 (any edition).
17. A. Shoamanesh and L. Shafai, "Properties of Coaxial Yagi Loop Arrays," IEEE Transactions Antenna Propagation, July 1978.
18. A. Shoamanesh and L. Shafai, "Design Data for Coaxial Yagi Array of Circular Loops," IEEE Transactions Antenna Propagation, September 1979.
19. James L. Lawson, *Yagi Antenna Design*, ARRL, Newington, Connecticut, 1986.
20. John D. Kraus, *Antennas*, McGraw-Hill, New York, 1950.
*References 1-15 are found in part 1.

ham radio

LET THE SUN DO THE WORK



- Charge batteries on stored machinery
- Light your tent
- Run fans
- Run remote transmitters
- Light signs
- Pump water for your animals
- Power for your motor home
- Run your radio without batteries
- Light your home
- Yard lights
- Charge flashlight batteries
- Light your cabin
- Run electric fences
- Charge your boat battery
- Run appliances in your home
- Charge hand held radio batteries
- Fish shanty lights
- Charge your Camcorder battery pack

Electricity from the Sun with

SOLAREX™ Solar Systems

ALSO: *OUTSTANDING* PRICES ON IBM XT COMPATIBLE SYSTEMS!

SHIPPING INFORMATION: PLEASE INCLUDE 10% OF ORDER FOR SHIPPING AND HANDLING CHARGES (MINIMUM $2.50, MAXIMUM $10). CANADIAN ORDERS, ADD $7.50 IN US FUNDS. MICHIGAN RESIDENTS ADD 4% SALES TAX. FOR *FREE* FLYER, SEND 22¢ STAMP OR SASE



HAL-TRONIX, INC.
12671 Dix-Toledo Hwy
P.O. Box 1101
Southgate, MI 48195

(313) 281-7773
Hours
12:00 - 6:00 EST Mon-Sat

"HAL" HAROLD C. NOWLAND
W8ZXH

159

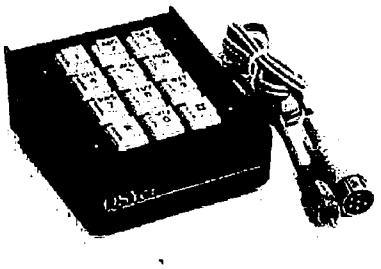
NEW products

high-speed frequency entry for Kenwood transceivers

Kenwood rigs now feature the KW-QSY frequency-entry keypad. The QSYers provide a means for high speed and simple frequency selection.

The QSYer is a tiny computer terminal with its own internal 8-bit microprocessor and support circuitry. Its full-size telephone-type keypad is inclined at a 10 degree angle. The unit is housed in an all-metal enclosure measuring 3.1" x 3.5" x 2" and has an internal speaker that sounds a different tone for each key.

The KW-QSYer works with the TS-940 series (with the Kenwood IF-10B interface installed), TS-440 series (with IC-10 installed), TS-140 series (with IF-10C installed), and TS-711/811 series (with IF-10A installed). It requires an 8-16 volt, 100 mA, external dc supply.



The KW-QSYer (and its sister models for the 757GX, 757GX-II, 767GX, and the IC-735) are available from Stone Mountain Engineering Company. All are priced at $89.50, plus $2.50 shipping. A companion 12-volt dc wall supply for the KW-QSYer is $10. For more information write to Stone Mountain Engineering Company, P.O. Box 1573, Stone Mountain, Georgia 30086.

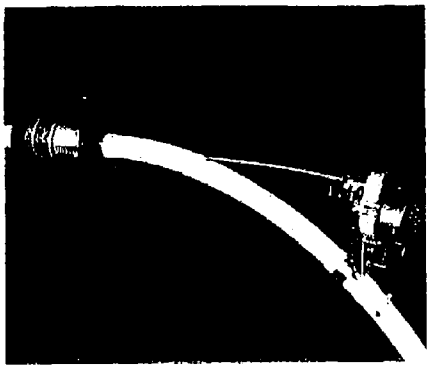
Circle #301 on Reader Service Card.

new twist to old antenna concept

DMQ offeres an antenna designed to cover all frequencies between 13 MHz and 30 MHz, while maintaining a better then 2.1 SWR and handling up to 250 watts P.E.P. Targeted at the Amateur with limited space, it is a loop standing on end with an approximate diameter of 36 inches. The antenna is connected through a standard SO 239 fitting directly to your 52-ohm coax transmission line. No external matching unit, pretuned coax line, ground screen, or radial system is needed.

Frequency resonance is obtained by adjusting a special high-voltage vacuum variable capacitor. The antenna is made of high quality copper; the vacuum variable capacitor is a glass-type design. All metal surfaces are chemically cleaned and covered with two coats of exterior enamel paint.

The antenna has a bidirectional radiation pattern. The high-Q design is stable to frequency and provides a high level of harmonic suppression. Pattern gain is developed throughout the antenna's frequency range.



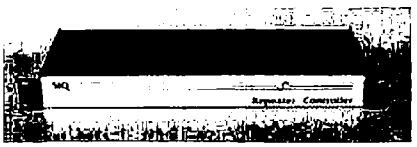
The antenna has a mounting hook, nylon line, and tuning wand supplied. The antenna can be suspended from the ceiling of the Amateur's apartment; outdoor installations are also feasible.

The antenna comes assembled and ready for use. It is factory adjusted for the 15-meter Novice portion of the band. The unit price is $349.50, plus shipping and handling in the continental U.S. For information contact DMQ Technology, 221 Slater Boulevard, Staten Island, New York 10305.

Circle #302 on Reader Service Card.

SIQ repeater controller

A-Tech Electronics announces the SIQ Repeater controller. Using the power of a microcomputer, the SIQ-2 provides basic repeater functions, voice ID, programmable Morse code ID, autopatch, reverse autopatch, audio mixing, linking, and more.



The SIQ controller comes with an rf-proof rack mount box and all 16 I/O lines have rf beads to prevent rf problems. The manual contains detailed information on connecting your radios, programming the features, and user commands. The software listing is provided for making custom modifications.

An optional phone patch board is available. Up to five area codes can be programmed to help control long distance access.

The features are controlled by touch-tone commands. Courtesy tones, tail squelch length, CW ID, sleep/wake up mode, alarms, and other control commands are all remotely programmable. Sixteen I/O lines are provided.

The SIQ rack mount steel enclosure has D-style connectors. The user manual contains hookup and command instructions, an electronic schematic of the system, and source code listing.

The SIQ repeater controller retails for $349.95; the SIQ with phone patch is $449.95. Contact A-Tech Electronics, 1033 Hollywood Way, Burbank, California 91505 for more information.

Circle #303 on Reader Service Card.

new code and theory course audio cassettes

Amateur Radio School announces the addition of "The Video Novice" to their line of code and theory courses on audio cassettes.

The course material contains two VHS video cassettes, each two hours in length, one C90 audio cassette, and a manual study guide. Cassette No. 1 has two hours of theory; cassette No. 2 has one hour of theory and one hour of visual code class.



The course is aimed at the person who has limited understanding of electronics. It covers all the subjects that the person new to amateur radio needs to know with practical demonstrations and explanation. The Video Novice Course is just $39.95 plus $5.00 for postage and handling.

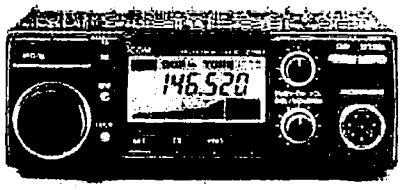
For more information, write to Jerry Ziliak, KB6MT, Amateur Radio School, 2350 Rosalia Drive, Fullerton, California 92635.

Circle #304 on Reader Service Card.

NEW products

new 2-meter mobiles from ICOM

ICOM has introduced the IC-228A, 25 watt, and IC-228H, 45 watt, 2-meter top-of-the-line mobiles. These compact models (5.5″ wide by 2.0″ high by 5.4″ deep and 6.2″ deep, respectively) have 13 front-panel controls for ease of operation. Both feature wideband Rx coverage of 138-174 MHz; Tx coverage is 140-150 MHz. Twenty memory channels with a lock-out function store the frequency. It has offset and subaudible tone for each memory. Both models feature programmable scan and memory scan, priority watch to monitor the call channel, a memory channel, or all memory channels every five seconds while operating on another frequency.



An optional UT-40 squelch unit emits a 30-second alarm when the frequency of a received tone equals the set tone frequency.

The suggested retail price of 25-watt IC-228A is $509.00; the 45-watt IC228H is $539.00.

For more information contact ICOM America, Inc., 2380 116th Avenue, N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.

Circle #309 on Reader Service Card.

tools for coaxial users

Mouser Electronics offers a Simplex Coaxial Cable Stripper, Crimping Tool, and a Strip'n Crimp Tool Kit for working with coaxial cable.

The cable stripper is 3.5″ long and can strip most coaxial cable from 3.6 mm to 7.6 mm. It comes with three-bladed preset cassette providing up to 5000 strips per cassette. Use the stripper for precision cutting through sheath, braid, and dielectric simultaneously or separately. Ask for Part No. ME382-CS1/3CBR.

The crimping tool is made of heavy gauge material. It has a controlled cycle mechanism for complete crimp, dual apertures for greater cable range, and a built-in release catch. This tool, Part No. ME382-DC89, comes with instructions.

The Strip'n Crimp Coaxial Tool Kit is a complete tool kit for coaxial users. Each kit contains a dual crimping tool, simplex cable stripper, ten plugs and cable sleeves for the following sizes; RG59, RG62, UR90, URM43, URM90, URM96, or 0.6/3.7 cables. Instructions are included with the kit. Ask for Part No. ME382-SNC5859.

A complete catalog is available free of charge. Contact Mouser Electronics, 2401 Highway 287 North, Mansfield, Texas 76063.

Circle #305 on Reader Service Card.

VR-1 voltage reference

The VR-1 is the latest product in the Sibex line of portable test equipment. The handheld precision voltage source is battery powered, and output is selectable from 10 mV to 10 V, in a 1-2-5 sequence, by the 11-position switch. Both + and − voltages are available at the output terminals. A low battery indicator is provided on the front panel. The unit is housed in a pocket-size plastic case; power is supplied by a standard 9-volt battery inside the case.



Units are available from stock and priced at $89.95. For information contact Sibex, Inc., 1088 Kapp Drive, Clearwater, Florida 34625.

Circle #306 on Reader Service Card.

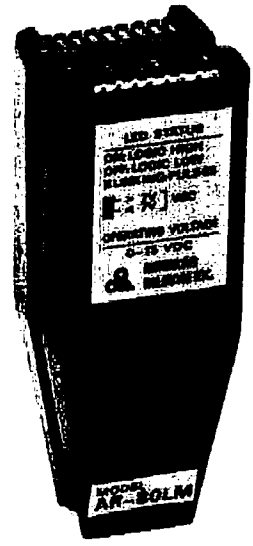
AR-80LM logic monitor

American Reliance has added the AR-80LM logic monitor to their logic measurement product line.

The custom-IC design provides autodetection of both power and ground pins, making instrument usage an easy, clip-on-and-view operation. The unit also autodetects both TTL and CMOS logic levels.

The unit provides indications for logic high, low, and pulsing inputs. For pulses with repetition rates over 8 Hz, the unit flashes the LED at an 8 Hz rate. This allows use of the unit at clock rates of up to 40 MHz.

The AR-80LM sells for a suggested user price of $79 and includes a storage case and operator's manual. For details contact ARI Media, 9241 E. Valley Boulevard, Suite 201, Rosemead, California 91770.



Circle #307 on Reader Service Card.

new mobile amplifiers and repeater controller

RF Concepts has two new all-mode solid-state rf power amplifiers and a new repeater controller.

UHF amplifiers are: model RFC 4-310, 30 watts in = 100 watts out, maximum input 35 watts; and RFC 4-110, 10 watts in = 100 watts out, maximum input 15 watts. Both use a GaAsFET receive pre-amp with 15-dB gain and a noise figure of 1.75 dB. They require 13.8 VDC, current, 25 ampere. Measurements are 11.5″L x 6″W x 3″H. The RFC 4-310 is priced at $324 and the RFC 4-110 is $349.

The repeater controller RFC 8-RC has a control system capable of handling all the requirements for large multiple-site interconnected systems as well as the simple repeater. The list price is $395.

RF Concepts products can be purchased from Amateur Radio dealers. For details contact RF Concepts, 2000 Humbolt Street, Reno, Nevada 89509.

Circle #308 on Reader Service Card.

Genius at Riverhead

Genius at Riverhead is the story of Harold H. Beverage, developer of the "Beverage Antenna".

This biography tells of Harold's travels and work with many of the leaders in the field of wireless and related sciences.

The 130-page book, with 35 photos, is available through the *ham radio* Bookstore for $15.95 plus $3.50 for shipping and handling.

remote base/simplex
phone patch controller

Control your station locally or from a distance

The terrain in my northern Alabama location is hilly and a large mountain blocks most of the targeted coverage area for 2 meters limiting my QSOs. I explored several solutions to the problem, including placing a repeater on a mountain top, and finally decided to use a box hooked to a simplex radio that can be remotely located and controlled from a standard touchtone telephone.

The box can be connected either to the Public Switched Telephone Network (PSTN) as in **fig. 1**, or at a local level with the circuit shown in **fig. 2**. It requires only the telephone and a few extra components. The station can be located in the garage, with the telephone the only radio "apparatus" in the family room. Add a speaker phone for general monitoring and use the handset for private conversation.

making it secure

After completing the hardware design, I addressed the issue of security. Could I limit transmitter access to ham operators only and maintain a reasonable amount of control during operations involving non-hams?

I solved the first problem by using an access code to activate the transmitter. To control operations involving non-hams, I decided to limit all communications from the telephone line to a 30 second maximum transmission time. If the telephone line carrier keeps the transmitter on past this time, the transmitter drops out and allows no further transmissions from the telephone until the box receives instructions from the control operator.

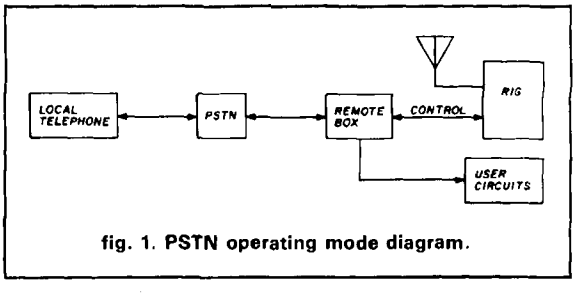


fig. 1. PSTN operating mode diagram.

operation

Begin operation by calling the remote unit from a remote telephone. After the selected number of rings you will hear the remote unit activate. You are now in the receive or monitor mode. Always listen for traffic already in progress before transmitting.

To transmit, enter your access code then press the # key and then the 9 key. After transmitting, depress the 9 key and the transmitter will deactivate. To transmit again, you need only hit the 9 key.

Terminate the call by hanging up or hitting the #; the remote unit automatically shuts down. Time-out timers allow transmissions of only 30 seconds or less.

Once the access code is entered, you can go into vox mode at the remote site by entering # and 0. The transmitter keys whenever you speak into the telephone. If the transmitter is keyed for longer than the allowed time, the remote unit will deactivate it and prevent further transmissions until the carrier from the telephone drops out and instructions are received from the control operator. To exit this mode enter # and

By Roger Owens, AA4NX and Jeff Owens, KK4LA, P.O. Box 277, Owens Cross Roads, Alabama 35763

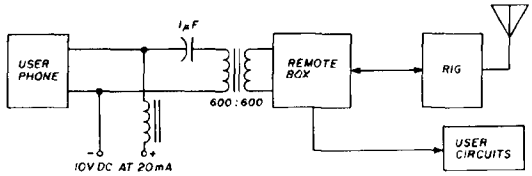


fig. 2. Private line operating mode diagram.

wait for an answer. The remote unit automatically goes into the vox mode. The operator has control of the remote unit and can terminate the call. Calls are limited to 3 minutes; all long distance calls are prevented.

digital circuitry

A microprocessor reduces the number of components (see the block diagram in **fig. 3** and circuit in fig. 4). I used the 80C31 because of its timers, on-board RAM, interrupt structure, and special function

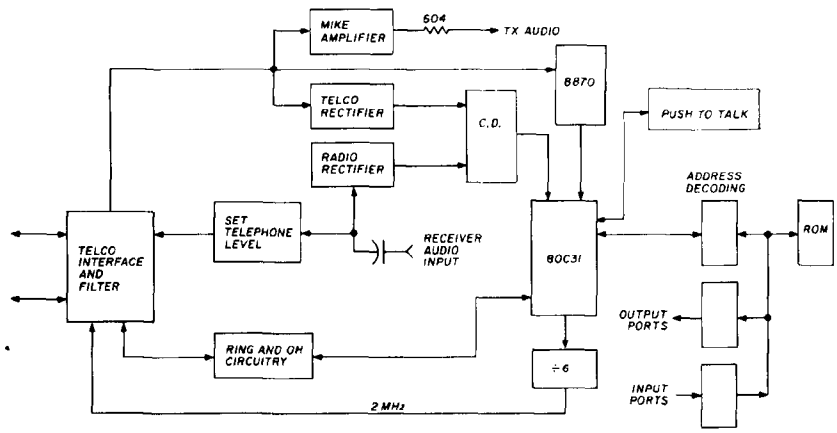


fig. 3. Functional block diagram.

0 from the local site. This returns the remote to monitor mode.

status indicators

Several indicators built into the software routines determine the status of the remote unit:

- CD—Main carrier detect.
- RADCD—Carrier detected is from the radio receiver.
- TELECD—Carrier detected is from the telephone line.
- OH—Remote unit is in the off-hook condition.
- PTT—Remote unit has the transmitter keyed.
- ACCESS—Remote unit has accepted access code.

Table 1 lists commands which activate specific output port pins. They are used to turn on NPN switching transistors that drive external control relays. These relays in turn activate additional functions through touchtones (DTMF) from a telephone or radio.

Mobile operation requires a touchtone generator. To call, enter your access code then send the * and 0 command to the remote unit. This takes the unit off hook and keys the transmitter for 3 seconds to acknowledge the dial tone. When the transmitter drops out, dial your number, listen for ring back and

Table 1. User defined port definitions.

Port A

Output bit-function	Output bit-function
1—TELCAR	5—SPARE
2—RADCAR	6—SPARE
3—PTT	7—SPARE
4—OH	8—SPARE

Port B

Output bit-function	Output bit-function
1—#1	5—#5
2—#2	6—#6
3—#3	7—#7
4—#4	8—#8

(User defined)

registers. The 80C31 also has various op-code instructions which operate on internal and external bytes and bits for programming ease.

The microprocessor is configured as follows: Port 0 is used as a multiplexed port in conjunction with the 74HCT373 eight-bit latch to separate the lower order address from data. This occurs each time address latch

Look at our MOBILE MARK™
"ON WINDOW" Line
PATENTED

VHF
(140-175)
- No Hole
- Easy to Mount
- Rugged
- Superior Performance
- Radiator Snaps On and Off
- Competitively Priced



UHF
(420-520)
- 3 db gain
- No Hole
- Easy to Mount
- Rugged
- Superior Performance
- Radiator Snaps On and Off
- Competitively Priced

220 MHz NOW Available!

MOBILE MARK, INC
COMMUNICATIONS ANTENNAS
152

9001 Exchange Ave • Franklin Park, IL 60131 • 312-671-6690

brings imagination and innovation to antennas ..... and has been since 1948 !!

INTERNATIONAL MONTHLY MAGAZINE BY AND FOR ACTIVE RADIOAMATEURS

Radiosporting

THIS IS IT! - FOR BIG GUNS & LITTLE PISTOLS

A magazine dedicated to quality and sportsmanship in amateur radio operating. Fresh, timely, practical and down to earth reading for little pistols and big guns. Written by the world's best in their fields: ON4UN, SMØAGD, LZ2CJ, VE3BMV, KH6BZF, DJ9ZB, ZS6BRZ, W1WY, N2SS, K7GCO, K4ZN, W4GF, VE3JTQ, WB4ZNH, WB9TBU, KQ2M, NS6X, W2XQ, W3FG, KA3B, K1PLR, N3IK, N7CKD, VE3XN, AØX, JE1CKA and others.

Includes DX News, QSL Info, 160m, 80m, 10m, 6m columns, DXpeditioning, Propagation, Awards, Contest Rules and Results, Traffic - Emergency, FCC News, New Products, Antennas, Technical News and articles, Equipment Reviews and Modifications, Computer Programs, Radio Funnies, Club Life, SWL, RTTY, VHF/UHF, Mail Box, Classified Ads and much more in a magazine format with the speed of a bulletin. RADIOSPORTING sponsors DX Centurion Award, Contest Hall of Fame and World Radio Championship contest.

"Your publication is superb! Keep it up!" Joe Reisert, W1JR

"Your W2PV articles are priceless. Your magazine is super!" Rush Drake, W7RM

"Let me congratulate you on a very impressive magazine. Just what I've been looking for as a DXer and Contester!" Dick Moen, N7RO

"RADIOSPORTING, once received, cannot be tossed aside until it is read from cover to cover. Then reviewed again and again." Chas Browning, W4PKA

"I take every ham magazine and can say without reservation that RADIOSPORTING is the first one read each month." Joe Rudi, NK7U, "Oakland A's"

Subscription rates: 1 year USA $18, Canada CDN$28, Overseas US$25; 2 years $33, $50, $44 respectively. Single issue $2.

USA First Class Mail add $10/year, DX Air Mail add $20/year.

TRY US! SUBSCRIBE OR SEND $1 FOR YOUR SAMPLE COPY. *VISA, MASTERCARD accepted.*

RADIOSPORTING Magazine
PO Box 282, Pine Brook, NJ 07058, USA Tel. (201) 227-0712

153

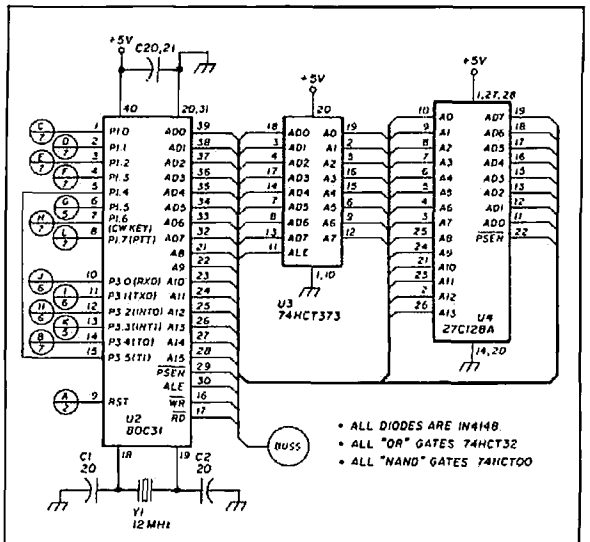


fig. 4. "Brain" of controller is 80C31 microprocessor.

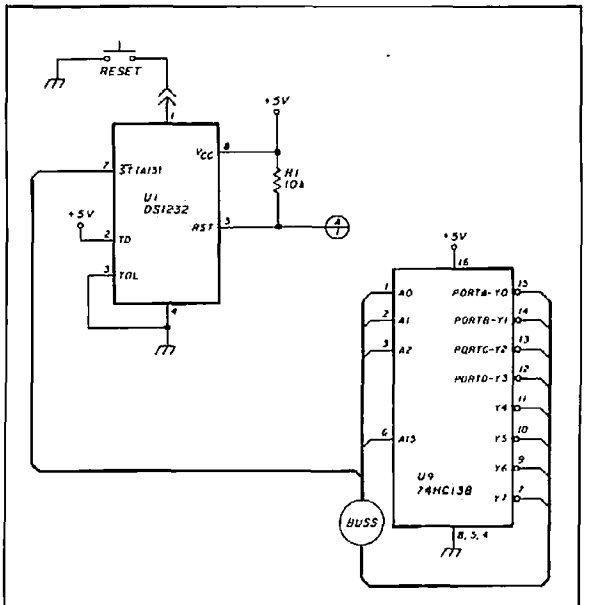


fig. 5. Dallas Semiconductor DS1232 is used as reset and watch dog timer.

enable (ALE) goes high. Port 2 serves as the higher order program address lines.

I selected this microprocessor, driven by a 12-MHz crystal, for its proper timer operation (which I will describe later). Port 1 serves as both the input and output port for the system. Port 1 bits, 0 through 3, are used as input data from the DTMF receiver. Port 1 bit 4 is used for an output pin for the 1-kHz clock, generated by the real-time clock routine in the software.

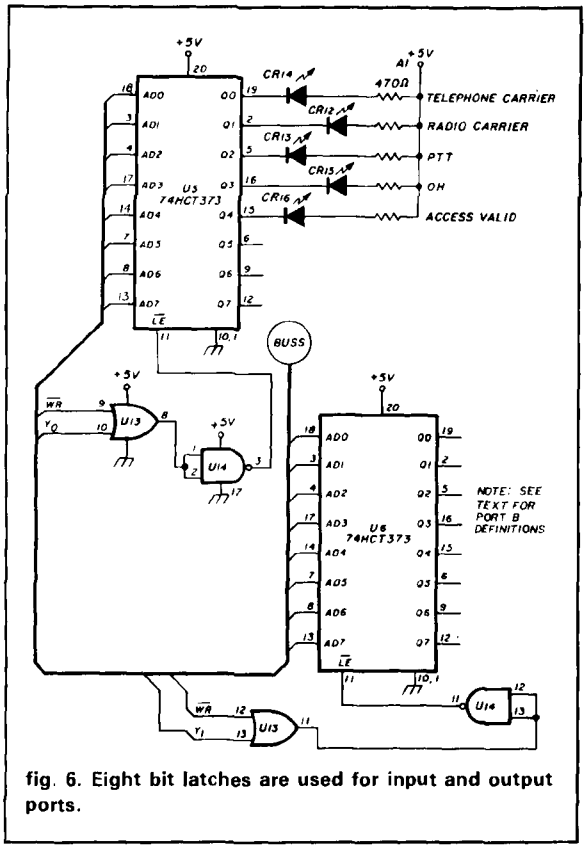


fig. 6. Eight bit latches are used for input and output ports.

Port 1 bit 5 is used as an output control pin to make the off-hook (OH) relay active. This signal is generated when the unit is in private line (no dc), has detected the correct amount of ring cycles, or senses telephone line current. The tone generator is used for warning beeps and CW signal; Port 1 bit 6 is used to turn it on and off. Port 1 bit 7 is used as the push-to-talk (PTT) signal to the radio transmitter whenever a transmission is requested.

Port 3 provides the system's interrupt scheme. Input pin 2 is an edge-triggered interrupt used for main carrier detection. Input pin 0, in conjunction with the main carrier detect bit, tells the microprocessor that the carrier is from the telephone lines. Input pin 1, along with the main carrier detect bit, tells the microprocessor that the carrier is from the radio.

Input Port 1 pin 3 is an edge-triggered interrupt that indicates the presence of a ring signal or telephone off-hook current.

Input Port 1 pin 4 tells the microprocessor that the carrier is a valid DTMF signal.

Input Port 1 pin 5, the input to a timer interrupt, generates a 1-second interrupt to drive the time-out timers and long delays. The remaining bits of Port 3 generate the system read and write signals.

The microprocessor reset is input on pin 9. A Dallas Semiconductor DS1232 is used as the reset and watchdog timer in this system. To prevent a reset signal from being generated, this reset circuit (**fig. 5**) must be written to by software at a periodic rate. A reset signal is also generated if the power drops below a predetermined level. This chip can save you trips to your remote site, but is not necessary for this application. A simple RC network can also be used to generate a reset signal on power-up.

The program memory used is a 16K x 8 EPROM (27C128A), as seen in **fig. 3**, chosen to allow for expansion.

I needed extra input and output ports to provide for the input and output of control signals. The 74HCT138 is used to decode external addresses for these ports. Only four ports are used; four more are held in reserve for expansion. All input and output ports (see **fig. 6**) use an eight-bit latch (74HCT373). Ports A and B are used for output; Ports C and D are for input.

The write signal for the output ports (see **fig. 7**) is generated by the selection of an address, NOR'ed with the system write signal. This scheme is used for all

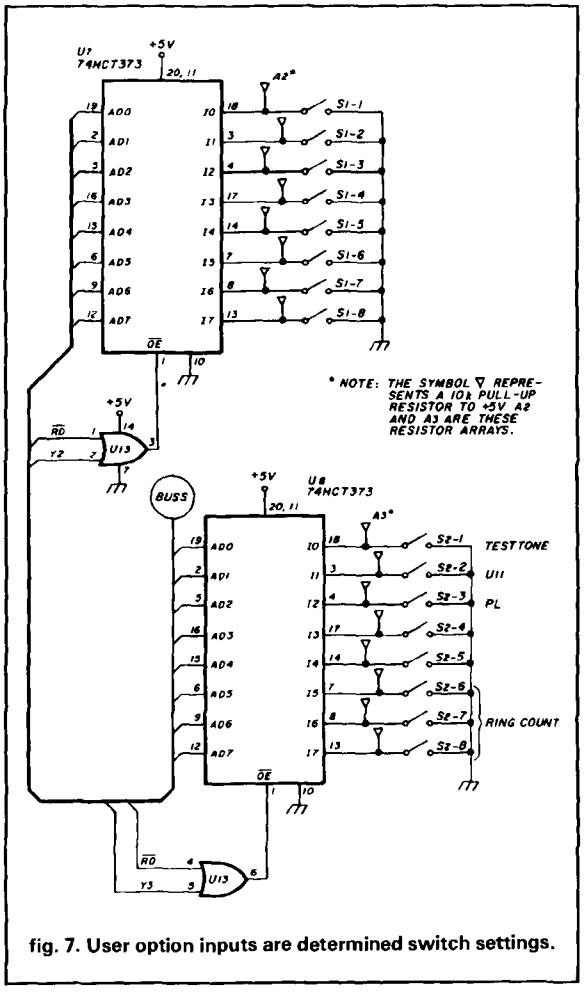


fig. 7. User option inputs are determined switch settings.

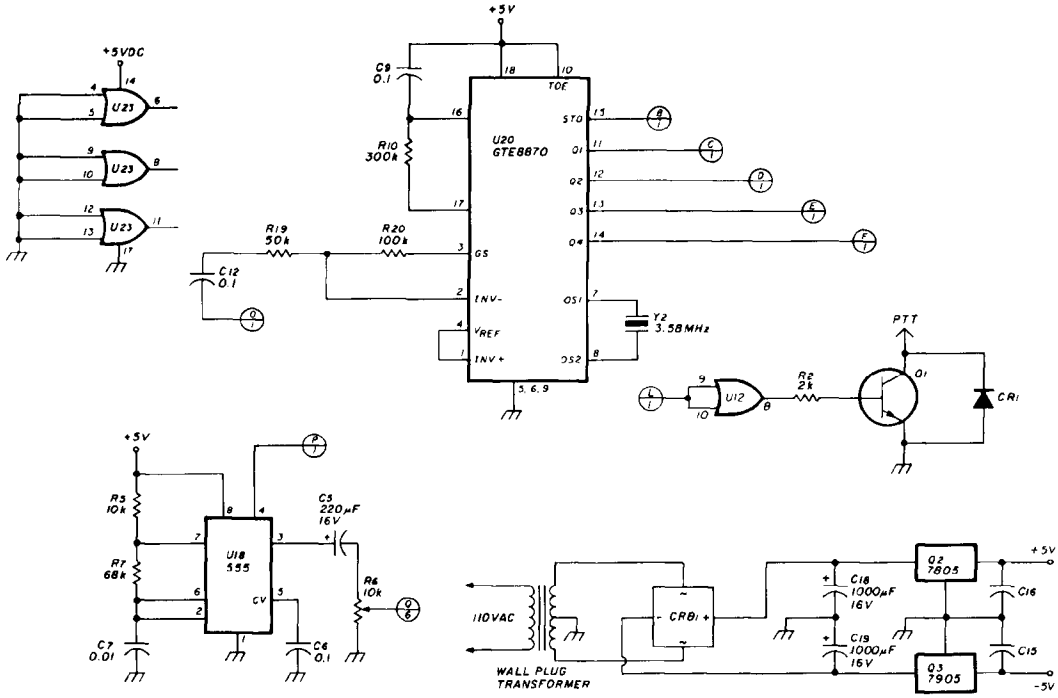


fig. 8. A GTE 8870 is used as a CMOS DTMF chip.

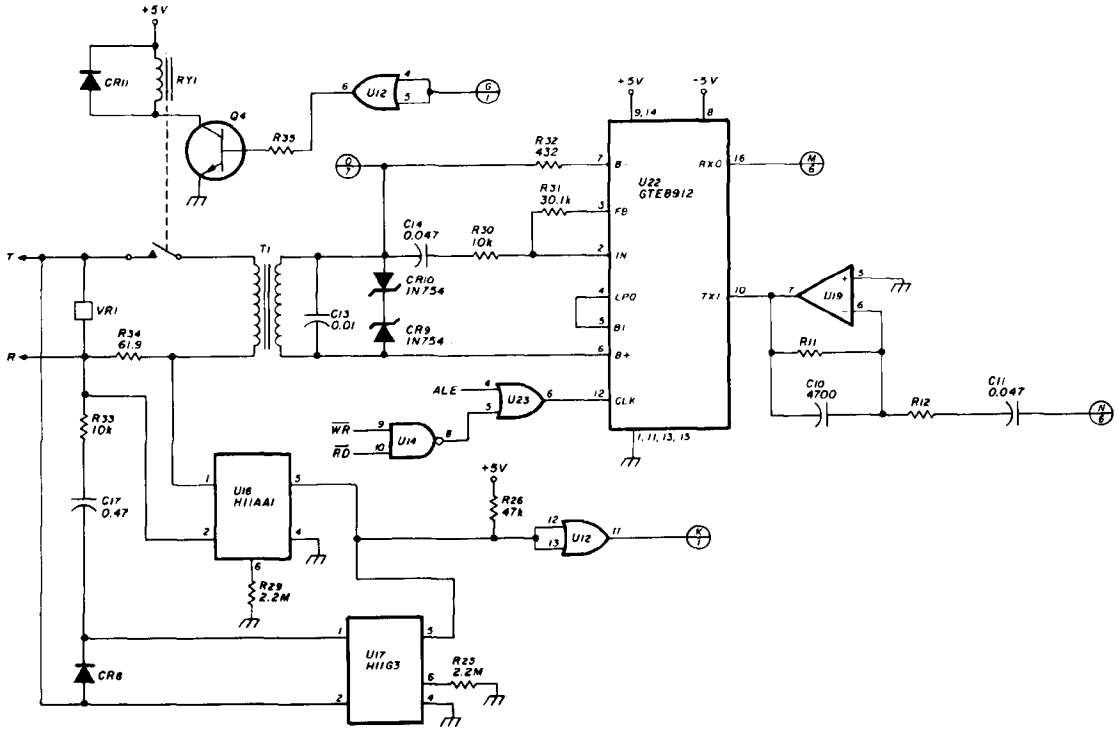


fig. 9. Analog circuitry part of controller.

external output ports. The read signal for the input ports is generated by OR'ing with the system read signal. Each input port bit is activated by opening the appropriate switch. The port pin is then pulled high by a pull-up resistor, telling the microprocessor it needs servicing.

DTMF signal decoding is done by the GTE 8870 CMOS DTMF chip (see **fig. 8**). Command signals may be entered into the system via the telephone line or radio receiver. When a valid DTMF signal is received, four bits are sent to the microprocessor input along with a strobe signal (std) telling the processor that the detected carrier is due to a DTMF signal. The processor then decodes this signal and performs the commanded task.

The tone generator consists of a 555 timer chip, set for a frequency of 1 kHz. The generator is turned on by a signal from the processor. The signal is capacitively coupled and the level set by a 10-k pot — one of the inputs to a summing amplifier that supplies audio to the radio transmitter.

analog circuitry

A description of the telephone interface circuitry (see **fig. 9**) begins with the ring and off-hook current components. The telephone network has a 600-ohm impedance, so transformer T1 is 600 to 600 ohms and meets FCC rules part 68: *this box does not have FCC registration.*

In an on-hook configuration, the dc path is broken by the off-hook relay. When a ring signal is applied across tip and ring, it is coupled through R_{33} and C_{17} from the ring side of the telephone line. The signal is then applied to the input of the H11G3 opto-isolator and CR_8, and the ac circuit is completed through these components and tip side of the telephone line. When the ring signal goes positive H11G3 turns on, pulling resistor R_{26} low, generating an interrupt to the processor during each positive portion of the ring cycle. The processor requires a count of ten cycles out of every cycle for a good ring. Once the accumulated rings reach the count, selected by ring 1 through ring 3 dip switches on Port D, the processor sends a signal to the off-hook relay closing the dc path. This causes current to flow through the 61.9-ohm resistor, generating a voltage drop which turns the H11AA1 opto-coupler on. A signal is then sent to the processor indicating that line current is present. This signal is sampled continuously, and if line current disappears for a certain length of time the processor sends a deactivate signal to the off-hook relay.

The telphone line side of the interface has a device to protect it from the possiblity of over-voltage spikes. The secondary side of the telephone circuit has both transmit and receive signal currents. The GTE 8912 PCM filter splits the signal into either a receive or transmit path. Two zener diodes prevent the PCM filter from overloading.

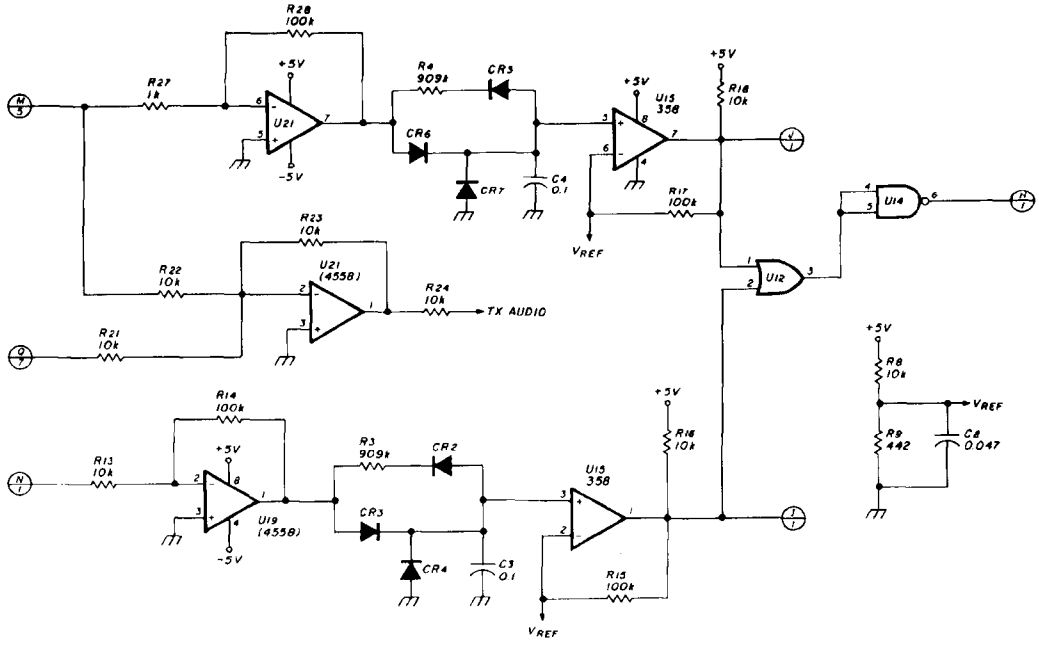


fig. 10. Carrier detect circuitry.

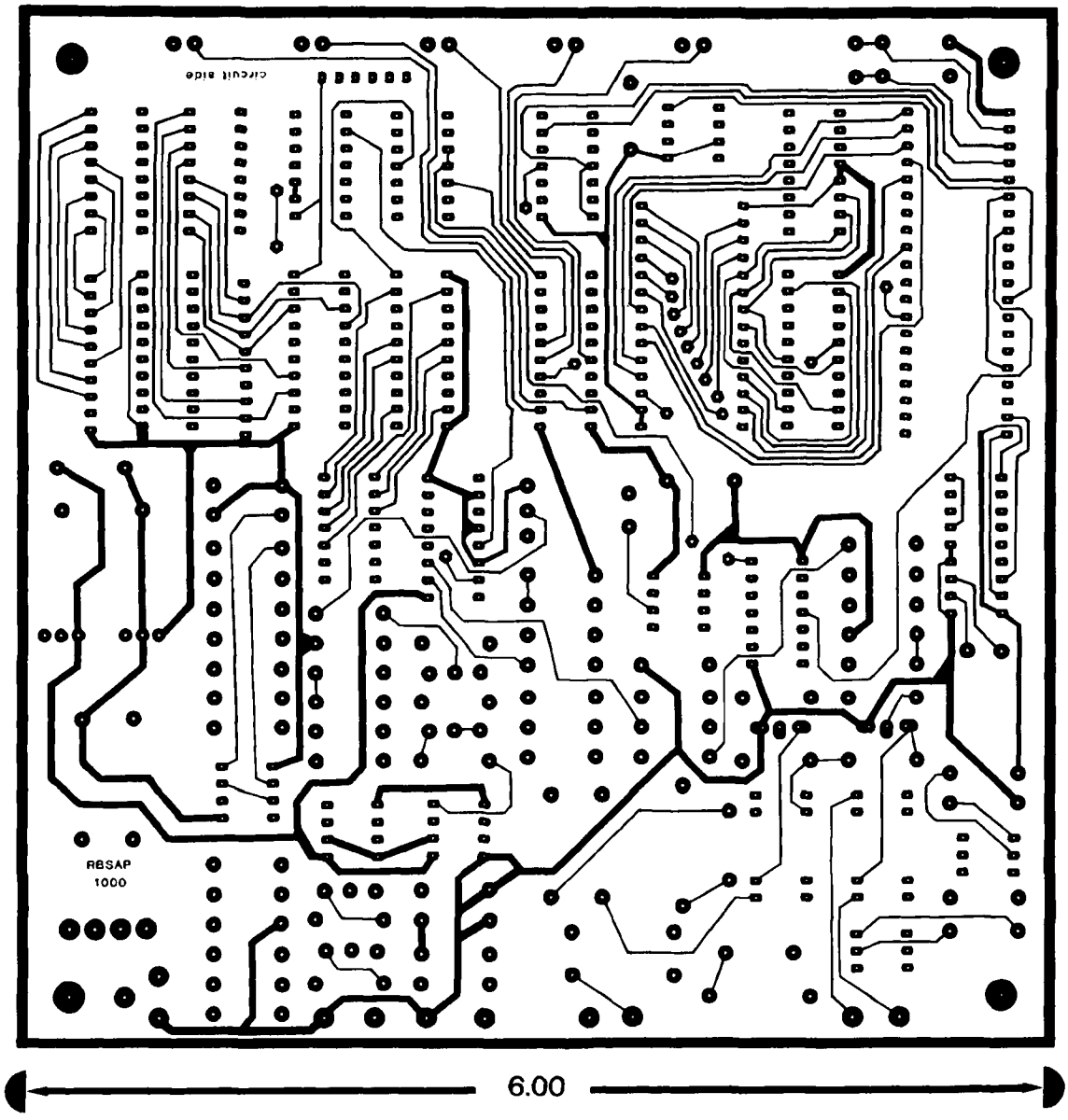


fig. 11. Printed circuit board artwork--component side.

The receive signal enters through C_{14} and R_{30}, with the gain resistor being R_{31}. The telephone output exits on pin 16 of the PCM filter. The radio receive signal enters the PCM filter on pin 10, and drives T1 through a differential amplifier in the PCM filter.

The DTMF receiver input is taken from the secondary side of T1, allowing command signals to be decoded from either the telephone or the radio receiver.

The PCM filter requires a 2-MHz clock signal to provide necessary filter characteristics. This signal is generated by first NAND'ing the system read and write signals, then OR'ing the result with the system ALE. As a result, the microprocessor clock frequency is divided by 6.

audio and carrier detect

The telephone signal to be transmitted leaves the PCM filter at pin 16 and then enters through R_{22} into a summing amplifier, where the CW tones are also mixed when required (see **fig. 10**). The amplifier's output goes to the radio microphone input through a 604-ohm resistor serving as an impedance-matching

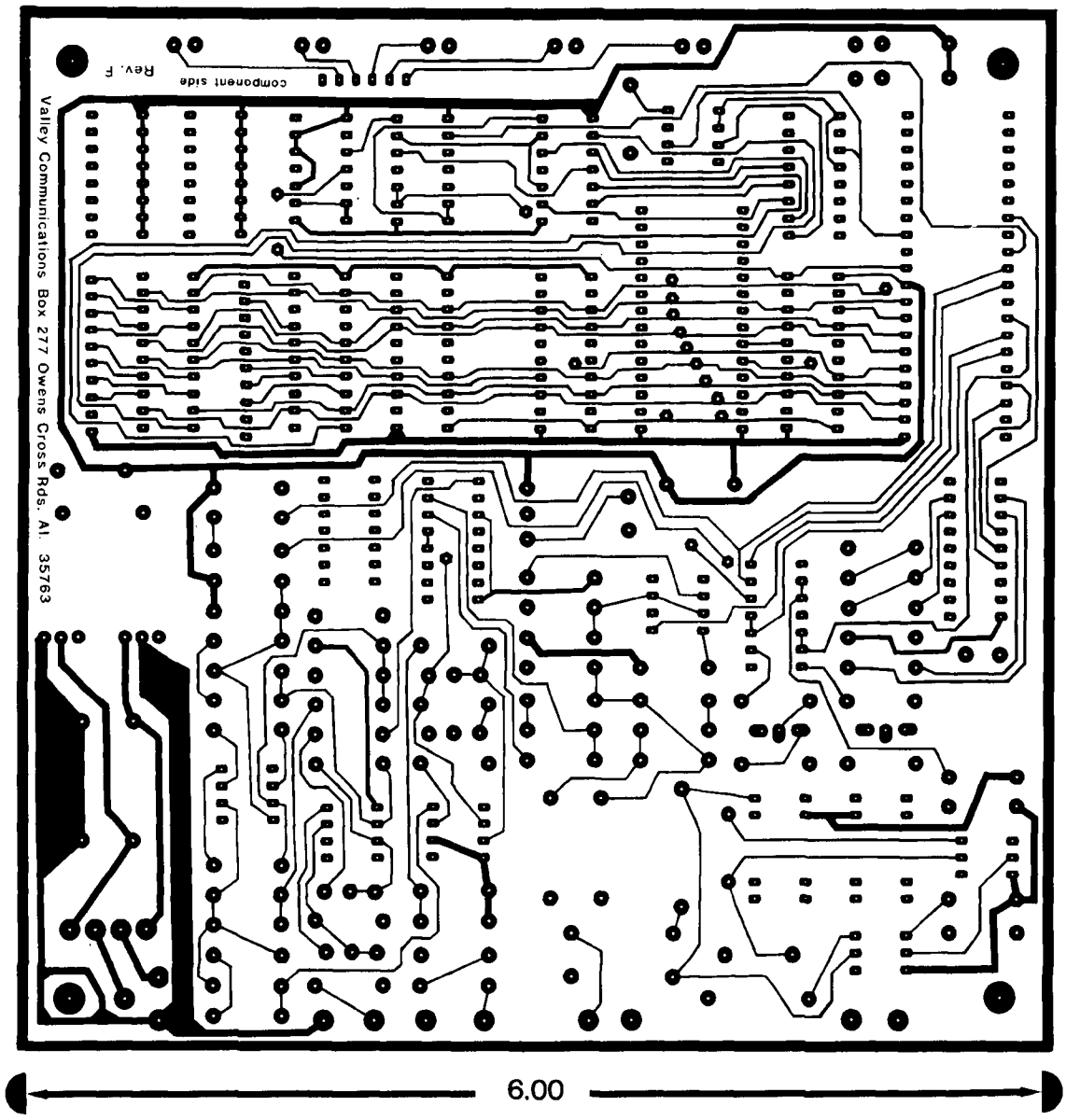
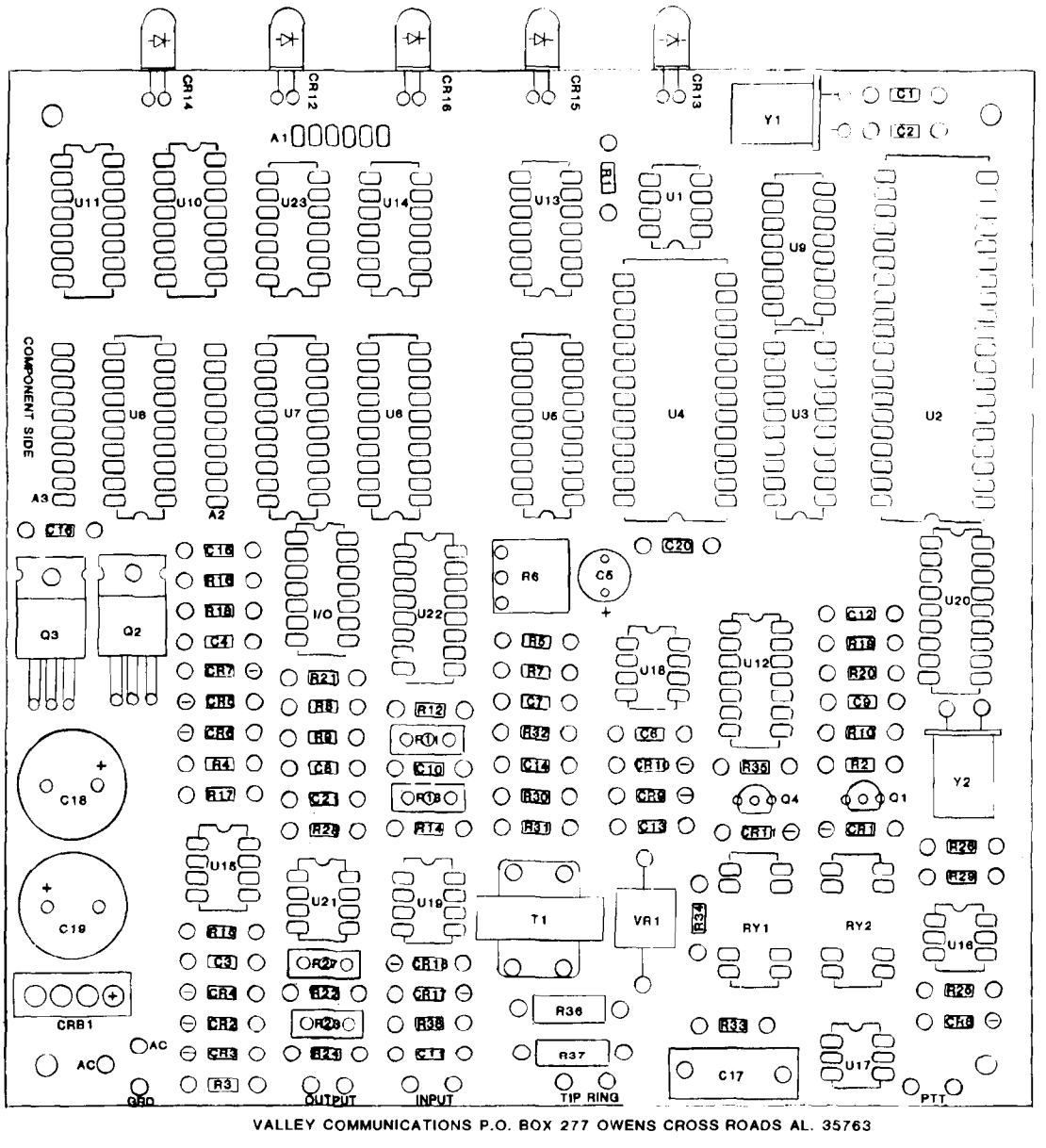


fig. 12. Printed circuit board artwork—non-component side.

device. This op-amp can be either an amplifier, attenuator, or buffer, depending on the ratio of R_{22} and R_{23}. In my application it was a buffer.

The telephone carrier detect circuitry has three parts: signal amplifier, rectifier, and comparator. The amplifier takes the incoming signal and amplifies it to a level sufficient for rectification. The gain is then set by the R_{27} and R_{28} ratio. Diode CR_6 half rectifies the signal allowing a positive voltage to be applied to the filter capacitor C_4. Voltage is applied to the input on a voltage comparator, U_{15}. When the voltage of the input signal rises above the voltage reference at pin 6, the output goes to a high state generating an interrupt through an OR gate. A signal is sent to the processor pin (described earlier) indicating the carrier is from the telephone. Resistor R_{17} provides a hysteresis effect in the comparator stage, preventing output chatter if the incoming signal received is close in level to the reference. Diode CR_5 and R_4 are used to forward bias CR_5. This discharges filter capacitor C_4 which removes the signal from the processor. Carrier detection has a fast attack and a slow decay. CR_7



VALLEY COMMUNICATIONS P.O. BOX 277 OWENS CROSS ROADS AL. 35763

fig. 13. Component layout superimposed on component side artwork.

prevents a negative voltage greater than 0.6 VDC from being applied to the comparator input. This will happen if the carrier stays off long enough — the circuit goes negative.

Radio receive signal path enters the system through C_{11} into a summing amplifier U_{19}. This amplifier takes the signal from the radio and amplifies it to a -9 dBm output on the telephone line. *Be sure your audio input level doesn't go above this level — it is the highest level permitted on the public switched system.*

Approximately 35 mV is all that is required to achieve this level. I found the audio input to the volume control was the best method of obtaining audio from the radio receiver. This level should not be varied during normal operation.

The radio carrier detect circuit is identical to the telephone carrier detect circuit.

strap option

Next select the parameters. Look over the functions of the Port C and D dip switches, and choose the ones for your application. (See **Table 2.**)

Table 2. Port C, D dip switch selections.

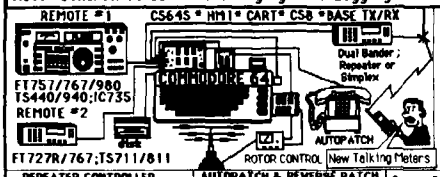
Port C (SW-1) Switch No./Function	Port D (SW-2) Switch No./Function
1—4 First digit of access code 0-9	1—Test of 1-kHz tone
	2—Expansion
	3—*Private line (no dc)*
	4—Expansion
5—8 Second digit of access code 0-9	5—Expansion
	6—Ring count 0 (LSB)
	7—Ring count 1 binary coded
	8—Ring count 2 (MSB)

construction

Construction isn't critical; I've included the artwork double-sided pc board (**figs. 11** and **12**) and the component layout (**fig. 13**). I used components that were easy to obtain. You can order a printed circuit board or any major parts directly from me. I would be interested in any comments or ideas you may have; for a reply please enclose an SASE. I hope you have as much fun with this project as I've had.

ham radio

*** Super Comshack 64 ***
Programable Repeater Controller/HF & VHF Remotes/Autopatch
Rotor Control/Voice Meters/ Paging/User Logging/Unlimited Vocabulary/BBS



Set up your **own personal repeater** with any Dual band radio from your home or club site. Operate cross-band for instant full duplex operation. You can have your own system! We will help you get your system operational! Hundreds of systems now in operation throughout the U.S. **Join the fun today!**

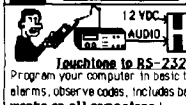
REPEATER CONTROLLER
*Change all variables remotely
*Synthesized voice adj pitch/speed
*Program mail box or select ID tail mess. with touchtones from HT
*Alarm clock & auto excute mode
*Macro commands/user **looping**
*Individual user access codes
*Code practice & voice readback
*Multifunction voice alarm clock
H.F. REMOTE #1
***20 Macro mem**/auto mode sel.
*Scan up/down sel. rate or step
*Voice ack. all control commands

AUTOPATCH & REVERSE PATCH
***1000 (18 digit)**Tel #'s stored
***300** users/CTCSS & 2 tone paging
***50** enable/disable tel #'s
*Directed/general & reverse page
*User progoms Tel. answer message
*Full or Half duplex (level cont.)
*Security mode/ TT readback on/off
*Store MCI/Sprint tel #'s
*Reverse Patch active all modes
*Call waiting/quick dial & reset
V.H.F. REMOTE #2
*Dual VFO's/ Rev/Split/COR detect
*Sel Scan inc. & offset/ver. resume

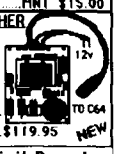
Super Comshack CS64S $349.95 + $4.00 ship USA; incl. computer interface, disk, cables & manual (simplex version inc. on request)

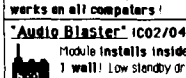
SYSTEM OPTIONS
*External Relay Control 3 DPDT relays + 5 open collector outputs...**CS-O $79.95**
*Beam control; speaks bearing and rotates beam ; 1 degree incre. **HM1 $49.95**
*2 Voice Meter & Alarm inputs/8 Ext On/off controls/Packet BBS **PK8 $149.95**
*EPROM Auto boot Cartridge customized with your system .....**CART $99.95**
*Manual (Refunded).....**MMI $15.00**

MINI (BEAR CAT) COMPUTER CONTROL FT-727R
Programs and Scans 100 ch. In Ham/General coverage. Converts HT into a powerful **100 ch. scanner** & programs all for field use!
*Digital "S" meter, stops scan from S(1-9), Auto resume
*Loads & programs all FT-727R parameters in less that 15 secs.
*Includes hardware & disk for C64 or IBM PC
MODEL 727S **$39.95**



12v C64 SWITCHER
*Draws 1.1A @12v
*70khz 75% efficient
*Outputs 5v @2 amps and 9 vac 60Hz
*Crystal time base
*Plugs into C64 power
MODEL DCPS.....**$119.95** NEW





Touchtone to RS-232 (300 baud interface)
Program your computer in basic to decode multidigit "strings", sound alarms, observe codes, includes basic program for C64 VIC20/C128, **works on all computers!**
MODEL OAP **$69.95**

Touchtone 4 Digit Decoder & on/off latch with all 16 Digits



Expendable Repeater on/off control

*Low power CMOS +5 to +12 Volts
*User programable **50,000**; 4 digit codes
*Send code once to turn on, again to turn off
*Momentary & Latch output drives relay
*Wrong digit reset; no falsing, 2 to 4 digits
*Mute speaker audio until call is received
*LED displays latch state, Optional 4 digit extra custom latch,(7225) IC's $6.95 ea.
***Model TSD $59.95**

"Audio Blaster" IC02/04;2AT;U16;FT209/727;23/73R
Module **installs inside the radio** in 15 Min. Boost audio to **1 watt**! Low standby drain/Corrects low audio/1000's of happy users. Miniature audio amplifier -->
Used by Police,fire, Emergency, when it needs to be **HEARD!**
MOV FOR FT78/28R ORDER MODEL AB1-B $22.95

MODEL AB1-**$19.95**

ENGINEERING CONSULTING ** 583 CANDLEWOOD ST. BREA, CA. 92621**
MASTERCARD ** VISA ** CHECK M.O. ** CA. RES. ADD 6% TEL: 714-671-2009**

NUTS & VOLTS MAGAZINE
P.O. Box 1111-H
PLACENTIA, CA 92670
714-632-7721

Ham Radio
Computer Hardware
Computer Software
Plans-Kits
Schematics
Test Equipment
CB Gear
Satellite TV
Video
Components
Antique Electronics
Cable TV
Publications
Repairs-Services
New Products
Events Calendar

IF YOU ARE INTO ELECTRONICS AND SAVING MONEY IS IMPORTANT TO YOU, THEN YOU OWE IT TO YOURSELF TO TRY NUTS & VOLTS MAGAZINE. DISCOVER WHY THOUSANDS OF SMART PEOPLE NATIONWIDE TURN TO NUTS & VOLTS EACH MONTH TO MEET THEIR ELECTRONIC NEEDS. WHETHER YOU'RE BUYING, SELLING, OR JUST TRYING TO LOCATE THOSE UNIQUE OR HARD-TO-FIND ITEMS, FIND OUT HOW NUTS & VOLTS CAN HELP!

SUBSCRIBE TODAY!
☐ CHECK ☐ MONEY ORDER ☐ VISA ☐ MC
Name _____
Address _____
City _____
State _____ Zip _____
Card No. _____ Exp. Date _____

CALL FOR ADVERTISING INFORMATION
DISTRIBUTOR INQUIRIES INVITED

Subscription Rates
U.S. FUNDS REQUIRED

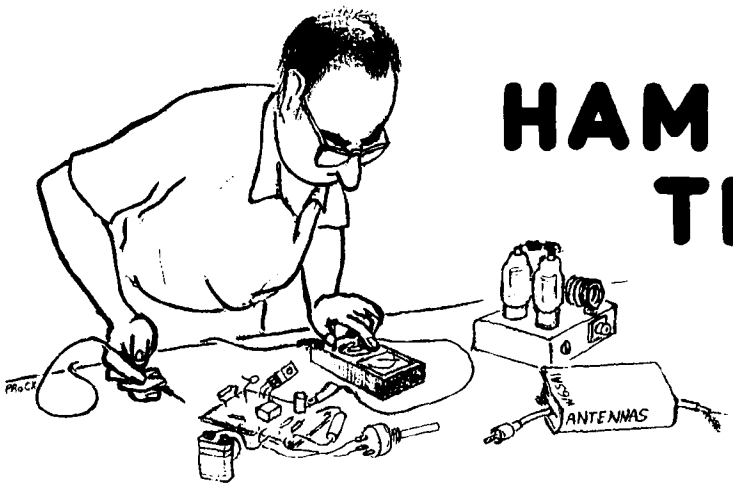
3rd Class Mail - USA
One Year $12.00
Two Years $21.00
Lifetime $60.00

1st Class Mail
One Year - USA . . . $20.00
Canada & Mexico . . $22.00

Air Mail
Foreign - 1 Year . . . $55.00

Includes one FREE 40-word Classified Ad

A National Publication For The Buying And Selling Of Electronic Equipment



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

the joys of TVI or, were you on the air last night?

Radio frequency interference (RFI) and television interference (TVI) have been around for years. In the last decade they have been joined by VCR, telephone answering machine, stereo, and cable TV interference along with other irritants that can drive an active Amateur crazy.

More and more household gadgets are susceptible to nearby rf energy. One cause of the proliferation of RFI problems is the deregulation of the telephone companies. Hundreds of new telephone gadgets are on the market, and many of them are poorly designed by manufacturers who know nothing of interference problems. A lot of the gadgets are so small and tightly packaged that there is no room inside them to install filtering.

Most of the VCRs, TV sets, and good AM/FM stereo systems built after 1984 seem to be more rf resistant than their ancestors; this is good news. However, it must be emphasized that the unwanted signal rejection varies between manufacturers and models and it is risky to assume a particular TV set or stereo is TVI resistant! This month's column concerns RFI problems associated with TV/VCR combinations and cable TV hookups.

One of the areas in the TV/VCR/cable field that bears close examination is common mode interference. John Norback, W6KFV, a technical consultant in the field of RFI, provided information on this subject.

common mode interference

The term "common mode current" originated with the computer industry. Before this the power and communication industries called the phenomenon "longitudinal line current" or "parallel line current".

Common mode interference is caused by parallel line current induced in a circuit normally carrying out-of-phase current. The unwanted current can be induced from a nearby Amateur transmitter. The signal is picked up by the TV feedline or cable system. The offending line serves as a good antenna for high-frequency signals.

In a balanced two-wire system (like a 300-ohm TV transmission line) the induced currents in the two wires are in the same phase. The ribbon line responds to the induced current as if the two conductors were tied in parallel to operate as one.

In an unbalanced system, like a coaxial line, the common mode picture is more complex. This is because the induced parallel line currents are not the same in both conductors (the center conductor and the shield). The induced current is much higher on the coax shield than it is on the center conductor (**fig. 1**).

In either case, the induced line current must go somewhere. Unfortunately, it goes into the TV tuner or VCR circuitry, through the various receiver stages, and then via capacitors to ground through the ac power cord of the receiver. Elimination of common mode interference must involve filtering, or breaking, both conductors of the TV signal lead-in.

Common mode interference is particularly bothersome on TV sets that are connected to cable TV systems. Even though the main cable system may be buried, it surfaces in the homes and acts as a pickup antenna for nearby, strong rf signals. Ground loops or poor joints in the system complicate the problem.

a practical approach to common mode interference

Television interference from receiver fundamental overload and transmitter harmonics has been well covered in the literature. The cures, too, are well known: a low-pass filter for the transmitter, a high-pass filter for the TV receiver, and a good ground for the

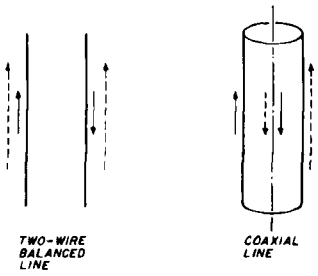


fig. 1. Common mode current (dashed line) is equal in each wire in balanced system but is unequal in coaxial system (right).

nels. Normally, common mode TVI will affect all TV channels, whether harmonically related to the ham signal or not, but the number of disturbed channels depends on the strength of the parallel line currents and how well the manufacturer has designed the TV set. (Note that a vertical transmitting antenna will cause a stronger common mode signal than will a horizontal antenna. Common mode interference can also exist on 40, 80 and 160 meters — bands not usually subject to harmonically related interference.)

Once you've determined which radio frequencies are causing the TVI, note the affected channels. It may be all of them, or just one or two. Disconnect the TV receiver from the input signal lead to the antenna or cable system and recheck the channels where there was interference. Normally, the channels will be clear. If interference still exists, a power line filter for the TV receiver may be needed, or external speaker lines of the receiver must be filtered. Solve the interference problem first.*

Once the TV set and/or cable TV converter are free from interference with the TV signal input lead disconnected, place a balun/high-pass filter/balun arrangement in the signal lead (**fig. 4**). The interconnecting leads should be as short as possible. A parts list is given in the drawing. Radio Shack parts were selected because they are widely available. Parts specifications are listed in case you select components from other manufacturers.

If everything's been done correctly up to this point, there should be no interference on the TV set regardless of transmitter frequency and TV channel selected. If you're still experiencing interference, install a coaxial high-pass filter between the cable TV converter and the TV set, as shown.

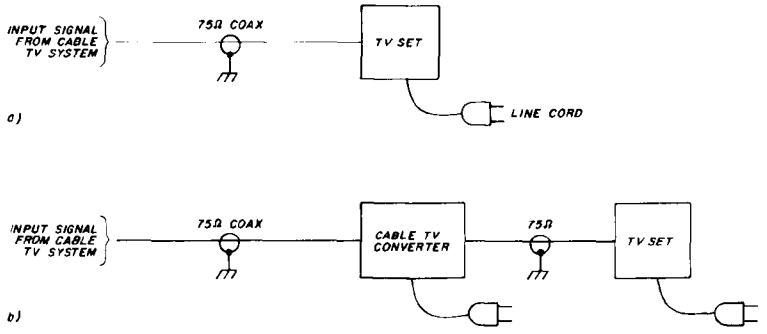


fig. 2. (A) Simple home cable TV setup with TV converter built into receiver. (B) Home cable TV setup with external converter. Some installations may have two or more additional TV sets installed. More complex installations involve FM, stereo systems, external speakers, etc. Do not forget these when investigating interference. All are suspect.

when a VCR is involved

The procedures for eliminating TVI in a cable TV system apply equally well when a VCR is involved, but the final solution may be more complex. There are many makes of VCRs and many different ways of connecting them into the cable TV system. They can be in series with the cable TV converter or TV set, or split off the cable TV input lead. **Figure 5** shows some typical arrangements involving VCRs along with the correct method of eliminating common mode interference.

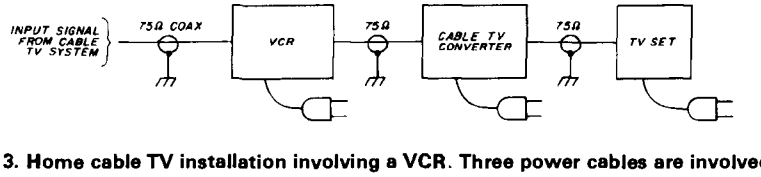


fig. 3. Home cable TV installation involving a VCR. Three power cables are involved, any one of which could pickup rf energy.

With the cooperation of the TV owner, first disconnect the cable TV shield of the coax line from transmitter to antenna. A power line filter may be required for the TV set as well as the transmitter. Unfortunately, these cures do not affect common mode interference to any substantial degree.

Figure 2 shows, in simplified form, the basic home equipment involved in a typical cable TV system. The first drawing shows a simple arrangement where the cable TV converter is built into the TV set; the second shows an arrangement where a cable TV converter is used to offer greater program selection. **Figure 3** shows an installation involving a VCR.

The cooperation of the TV owner is essential. First determine what ham band frequencies and TV channels are affected. Do not be fooled by interference on harmonically related TV chan-

*For detailed information on all aspects of interference (including interference to Amateur operation) the *Interference Handbook* by William R. Nelson, WA6FQG, an RFI investigator with 33 years experience, is available from *ham radio* Bookstore for $11.95 plus $3.50 shipping and handling.

SATELLITE CITY
Communications for the Future

• Dan "KBØXC" • Dave "WBØSNM"
• Denise "YL" • Maline "XYL"
• Dan E "SØØN" • Louis "KAØIPN"

YAESU

H.F. EQUIPMENT

FT-736R 2m/430 Full Duplex	1749.95 Call
FT-747GX, [illegible]-10m Xcvr	899.95 Call
FM-747	44.95 Call
FT-757 GX I	1129.95 Call
FP-757 GX	239.95 Call
FP-757 HD	299.95 Call
[illegible]	Call
[illegible]	Call
FRG-9600 60-9	699.95 Call
VU-9600 N.T.S.C. D/CNV.	25.00 Call

August Feature
5¢ SALE

HANDI-TALKIES

FT23R	299.95 Call
FT23R/TT	334.95 Call
FT 33R 2m FM w/touchtr[illegible]	344.95 Call
FT-33R/TT 220 MHZ FM[illegible].T.	389.95 Call
FT-73R [illegible] MHZ FM	309.95 Call
FT-73R/[illegible]	Call
FTT4 [illegible]	Call
FTS12	95 Call
	95 Call
	95 Call
[illegible]	Call
[illegible]	Call
[illegible]	Call
[illegible]	Call
FNB-[illegible]	Call
NC1[illegible]	89.95 Call
PA3	39.95 Call
FTS-6 CTCSS	49.95 Call

1/4 Wave Mag Mnt Antenna ONLY 5¢ with any 2 Mtr Mobile or Handi-Talkie Order
Offer good thru Aug 31

MOBILE/PORTABLE

FT-290R/II 2 MTR All Mode	599.95 Call
FT-690R/II 6 MTR All Mode	589.95 Call
FT-790 R/II 440 MHZ	799.95 Call
FT-4700 RII Dual Band	TBA Call
FT-211 RH 2m	389.95 Call
FT-311 RM 220 MHZ	429.95 Call
FT-711 RH 440 MHZ	449.95 Call
FT-212RH Hi-Tech 2m 45w FM	459.95 Call
FT-712RH Hi-Tech 70cm 35w FM	499.95 Call

ALINCO

ALR-22T 2m	409.95 Call
ALR-22 HT 2m	429.95 Call
ALR-72 HT 400 MHZ	469.95 Call
ALD-24T Dual Band	637.95 Call
ALX-2T 2m	235.95 Call
ELH 230G 2 MTR Amp 30WT	90.00 Call
ELH 230D 2 MTR Amp + PreAmp	108.00 Call
ELH 260D 2 MTR 50 WT Amp	167.00 Call

ARRL BOOK LIBRARY

1-800-426-2891
METRO 612-754-1200

HOURS M-F 10-8 Sat 10-5

Prices subject to change and availability.
12581 Central Ave. N.E., Blaine, MN 55434

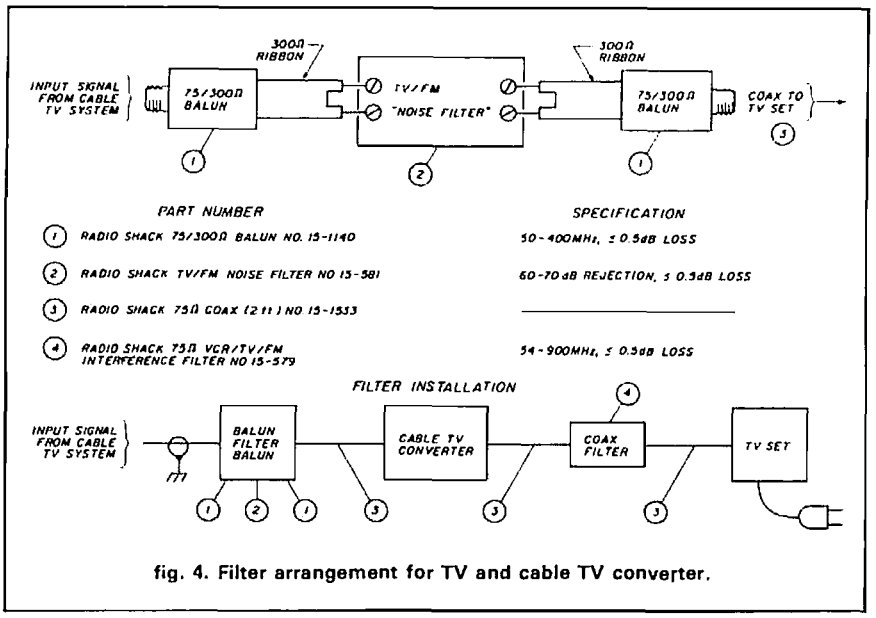


fig. 4. Filter arrangement for TV and cable TV converter.

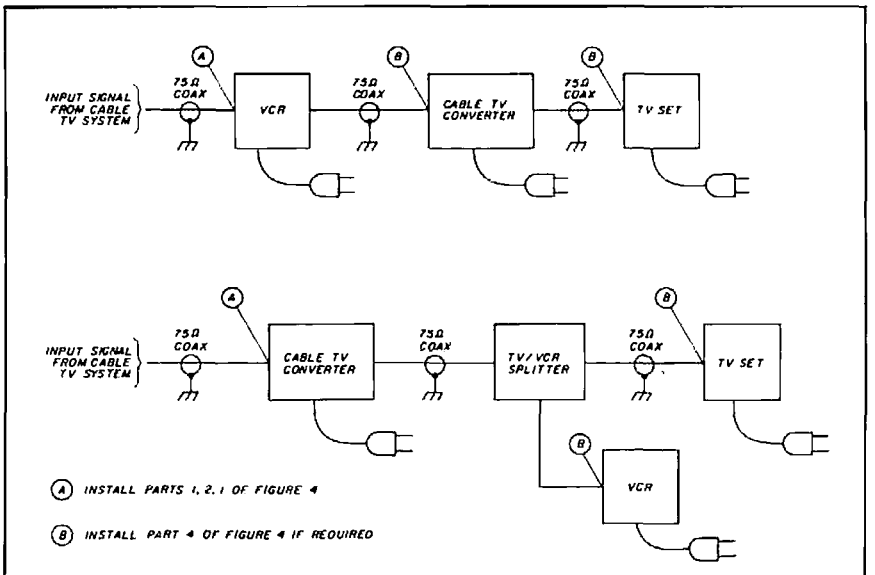


fig. 5. Filter arrangements for VCR installation. In case of severe interference install parts 1, 2, 1 of *fig. 4* here.

input signal lead from the circuit. Place a tape in the VCR and let it play, observing the picture on the TV set. Operate your transmitter on all hf bands, one at a time, and note any interference on the VCR picture. Also check all channels with the VCR inoperative but in the circuit. Identify any TV channels experiencing interference. If there is interference with the VCR operative, or unoperative but still in the circuit, install the balun/high-pass filter/balun arrangement discussed earlier between the cable TV signal input lead of the cable TV converter. If interference continues, disconnect the VCR from the circuit and repeat the tests with the TV converter in the circuit. You may need to insert a coaxial high-pass filter between the cable TV converter and the TV set.

These arrangements should solve

the interference problem with the VCR either on or off. If the problem continues, the interference may be in the VCR circuitry associated with the recording or playback heads, or it may be due to improper grounding or faulty connectons in the cable TV circuit. It's a good idea to contact the cable TV company involved and ask them to inspect their equipment for proper connections. Don't be surprised if the cable TV company inspects your station with a spectrum analyzer. If the cable company finds transmitter harmonics, you need to do more work on your installation, or you must investigate the possibility of external rectification. If the cable TV circuit is "clean", the problem lies in the VCR.

Because sensitive circuits of the VCR operate in the low-frequency portion of the 80-meter band, it is wise to restrict operation to the upper portion of the band until you solve the problem. Check with servicers of the VCR in question to see if any TVI corrective measures are available for that model. The VCR is a complicated electromechanical device and probing its "innards" is not recommended!

the Faraday solution

I received a note from Wayne Cooper, AG4R, outlining a system which "breaks" a TV coaxial line for protection against fundamental overload and

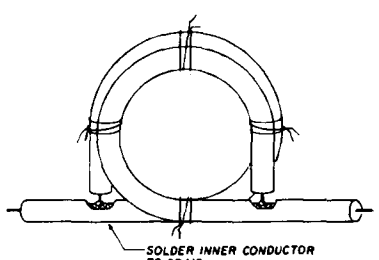


fig. 6. Tightly coupled loops break coax to cut fundamental overload and common mode currents.

common mode interference. The idea was sent to him by ZS6AUB, who got it from G3LLL. It consists of a 1:1 transformer in the antenna lead which will pass the VHF signal but will reject a lower frequency interfering signal. The idea is simple and inexpensive (**fig. 6**). The coax is cut about a foot from the TV receiver and two tightly coupled 2-inch diameter loops are formed. Each coax center conductor is soldered to the outer braid and cable ties or vinyl tape hold the loops together. This comprises an electrostatic shield. The coupling scheme has some loss and may make a weak channel more "fuzzy", but works okay when the picture is good to begin with.

another interesting quotation

Last month I intimated that radio hams are well-read, well-rounded individuals. As of this writing, the July column hasn't seen daylight, so I haven't received any response to my request for identification of a well-known quotation. Even so, I'm going to try again to see how alert my readers are. I suspect only the old-timers will identify the following; the book first came out in 1923. It created a sensation and is still a first-rate story (available in paperback). So, here's the quotation, which took the form of a telegram.

STORY TRUE. AWAIT ME ALGIERS. (signed) BURROUGHS

If you know the book and can identify the situation, drop me a note on your QSL to Box 7508, Menlo Park, California 94025 and I'll publish the calls of the erudite "winners" in this column!

ham radio

ALL BAND TRAP "SLOPER" ANTENNAS!



FULL COVERAGE! ALL BANDS! AUTOMATIC SELECTION with PROVEN Weatherproof sealed Trpps - 18 Ga Copperweld Wire! GROUND MOUNT SLOPERS - No Radials needed! Ground to rod or house water faucet! Connect Top to Trees, Buildings, Poles, etc at ANY angle from Straightup to 60 degrees for excellent "SLOPER" DX Antenna Gain or bend it anywhere you need to! 2000 Watt PEP Input, max. Permanent or portable Use installs in 10 minutes. SMALL - NEAT - ALMOST INVISABLE - No one will know you have a Hi-Power DX Antenna. Ideal For COND'Os APARTMENTS- RESTRICTED AREAS - Pre-tuned for 2-1 or less SWR over ALL bands (except 80-160-300hc) No adjustments needed - EVER. COMPLETELY ASSEMBLED, with 50 ft RG-58U Coax feedline and PL259 connector - Built in lighting arrestor - ready to hookup! FULL INSTRUCTIONS!

No. 10805 - 80-40-20-15-10 — 1 trap 49 ft.—$59.95
No. 1040S — 40-20-15-10 — 1 trap 28 ft.—$56.95
No. 1020S — 20-15-10 — 1 trap 13 ft.—$57.95
No. 10 16 S-160-80-40-20-15-10 - 2 traps 93 ft. - $59.95

SEND FULL PRICE FOR PPDEL IN USA (Canada is $5.00 extra for postage etc) or order using VISA, MASCARD - AMER EXP. Give Number Ex Date. Ph 1-308-236-6333 weekdays. We ship in 2-3 days (Per Cke 14 days) Guaranteed 1 yr - 10 day money back trial.

WESTERN ELECTRONICS
Dept. AH Kearney, Nebraska 68847

✓ 188

RF POWER TRANSISTORS

We stock a full line of Motorola & Toshiba parts for amateur, marine, and business radio servicing

Partial Listing of Popular Transistors
2-30 MHz 12V. (* 28V)

P N		Rating	Net Ea.	Match Pr.
MRF421	Q	100W	$24.00	$53.00
MRF422*		150W	36.00	78.00
MRF454, A	Q	80W	14.50	32.00
MRF455, A	Q	60W	11.75	26.50
MRF492	Q	90W	16.00	35.00
SRF2072	Q	65W	12.75	28.50
SRF3662	Q	110W	24.00	53.00
SRF3775	Q	75W	13.00	29.00
SRF3795	Q	90W	15.50	34.00
SRF3800	Q	100W	17.50	38.00
2SC2290	Q	80W	16.75	39.50
2SC2879	Q	100W	22.00	48.00

Q Selected High Gain Matched Quads Available

PARTIAL LISTING OF MISC. TRANSISTORS

BFR96	$2.75	MRF966	2.75
CD2545	16.00	MGF1402	3.75
MRF134	16.00	NE41137	2.50
MRF136	21.00	PT9847	21.00
MRF137	24.00	SD1278-1	17.75
MRF138	35.00	2N1522	11.95
MRF150	87.50	2N3553	2.25
MRF174	80.00	2N3771	3.50
MRF206	11.50	2N3866	1.25
MRF212	16.00	2N4048	11.95
MRF221	11.00	2N4427	1.25
MRF224	13.50	2N5109	1.75
MRF226	14.50	2N5179	1.00
MRF227	3.00	2N5589	7.25
MRF237	2.70	2N5590	10.00
MRF238	12.50	2N5591	13.50
MRF239	14.00	2N5641	9.50
MRF240	15.00	2N5642	13.75
MRF245	27.50	2N5643	15.00
MRF247	26.00	2N5945	10.00
MRF260	7.00	2N5946	12.00
MRF262	8.75	2N6080	6.25
MRF264	12.50	2N6081	8.00
MRF317	56.00	2N6082	9.50
MRF406	12.00	2N6083	9.75
MRF433	11.00	2N6084	11.50
MRF450	13.50	2SC730	1.25
MRF453	15.00	2SC1307	3.00
MRF458	20.00	2SC1946,A	15.00
MRF475	3.00	2SC1947	9.75
MRF476	2.75	2SC1969	3.00
MRF477	11.75	2SC2075	3.00
MRF479	10.00	2SC2097	28.00
MRF485	6.00	2SC2166	3.50
MRF485 MP-KEN	18.00	2SC2312	4.95
MRF492A	18.75	2SC2509	9.00
MRF497	14.25	2SC2630	28.00
MRF515	2.50	2SC2640	15.00
MRF555	3.00	2SC2641	16.00
MRF607	2.50	3N204	2.00
MRF630	4.25	40582	7.50
MRF641	18.00	OUTPUT MODULES	
MRF644	21.00	SAU4 450 MHz	55.00
MRF646	25.00	SAU17A 903 MHz	50.00
MRF648	31.00	SAV6 150 MHz	42.50
MRF660	10.75	SAV7 146 MHz	42.50
MRF837	2.25	SAV15 222 MHz	48.00
MRF846	43.50	M57712, M57733	use
MRF901	1.25	M57737, SC1019	SAV7
MRF911	2.00	SC1027	use SAU4

Hi-Gain, Matched, and Selected Parts Available

We stock RF Power transistors for Atlas, KLM, Collins, Yaesu, Kenwood, Cubic, Mirage, Motorola, Heathkit, Regency, Johnson, Icom, Drake, TWC, Wilson, GE, etc. Cross-reference on CD, PT, SD, SRF, JO, and 2SC P'Ns.

Quantity Pricing Available Foreign Orders Accepted

Shipping/Handling USA $5.00 COD VISA MC

Orders received by 1 PM PST shipped UPS same day. Next day UPS delivery available

PARTS ORDERS ONLY — NO TECHNICAL

(800) 854-1927

ORDER LINE and/or TECH HELP

(619) 744-0728

FAX 619-744-1943

RF PARTS

1320 Grand Avenue
San Marcos, CA 92069

precision high-voltage dc regulator

Convert an unregulated high-voltage power supply into a regulated adjustable voltage source

I have built a short-circuit proof, RFI resistant, solid-state precision regulator that converts an unregulated, high-voltage power supply into a stable, adjustable voltage source.

There are three prerequisites this unregulated power supply must meet:

- The minimum, full-load, unregulated voltage (including ripple) must exceed the regulated output voltage by ≈45 volts*.
- The unregulated supply must be capable of providing the additional 2.2 mA consumed by sampling resistor R_2 (**fig. 1**).
- The voltage difference between the unregulated supply and the regulated output must not exceed the voltage capability of the pass element.

applications

- Adjustable screen supply for tetrode or pentode class AB-1 grid-driven linear amplifiers (using a suitable (–) screen current bleeder resistor).
- Klystron and traveling wave tube amplifier power supplies.
- Backward wave and klystron oscillator power supplies.
- Plate supply for a linear amplifier.
- Any requirement for a regulated voltage up to 6 kV. 1000 amperes or more is possible if enough pass FETs and heat sinks are available.

* May be altered by using different values of R_1,R_2,C_6, and R_{11}.

limitations and design considerations

The output voltage capability of the regulator is indirectly set by the maximum voltage dropping capability of the FET pass element. The voltage difference between the unregulated supply and the regulated output voltage is wasted as heat by the pass element. Since only a small part of the input voltage appears across the pass element, the maximum output voltage capability of the regulator is about five to six times the maximum output voltage rating for the pass element. The Motorola MTM6N60 is rated at 6 amperes, 600 volts, 150 watts maximum. The highest regulated voltage with this pass element is about 3 kV. Similar FETs with ratings up to 1 kV at 150 watts (before thermal derating) per device are available. A 1-kV pass element can be used to regulate 6 kV. Current capability may be increased by paralleling pass elements.

Paralleling FETs is somewhat easier than paralleling bipolar transistors because the FET's control element (gate) consumes no power. Since 0 + 0 = 0, two or three FETs use the same driving power as one — exclusive of the gate capacitance and charge bleeder resistors from the gates to the sources. Driving the gate capacitances is a problem. Each gate adds about 1800 pF. If more than two MTM6N60s are to be paralleled, use an NPN emitter follower driver to drive the bank of FETs in the pass element. The pass FET source leads should have current equalizing resistors as paralleled, bipolar transistor emitters do.

A common reason for paralleling FETs is to obtain increased power dissipation instead of more current. Although a dissipation rating of 150 watts may look good, it is only true at 25 degrees C case temperature. One way to keep the case ≤25 degrees C, while dissipating 150 watts would be to immerse it in circulating distilled ice water. Because this is impractical, the device is derated according to the manufacturer's data sheet. An educated guess would be about 50 percent,

By R.L. Measures, AG6K, phone: 805-482-3034

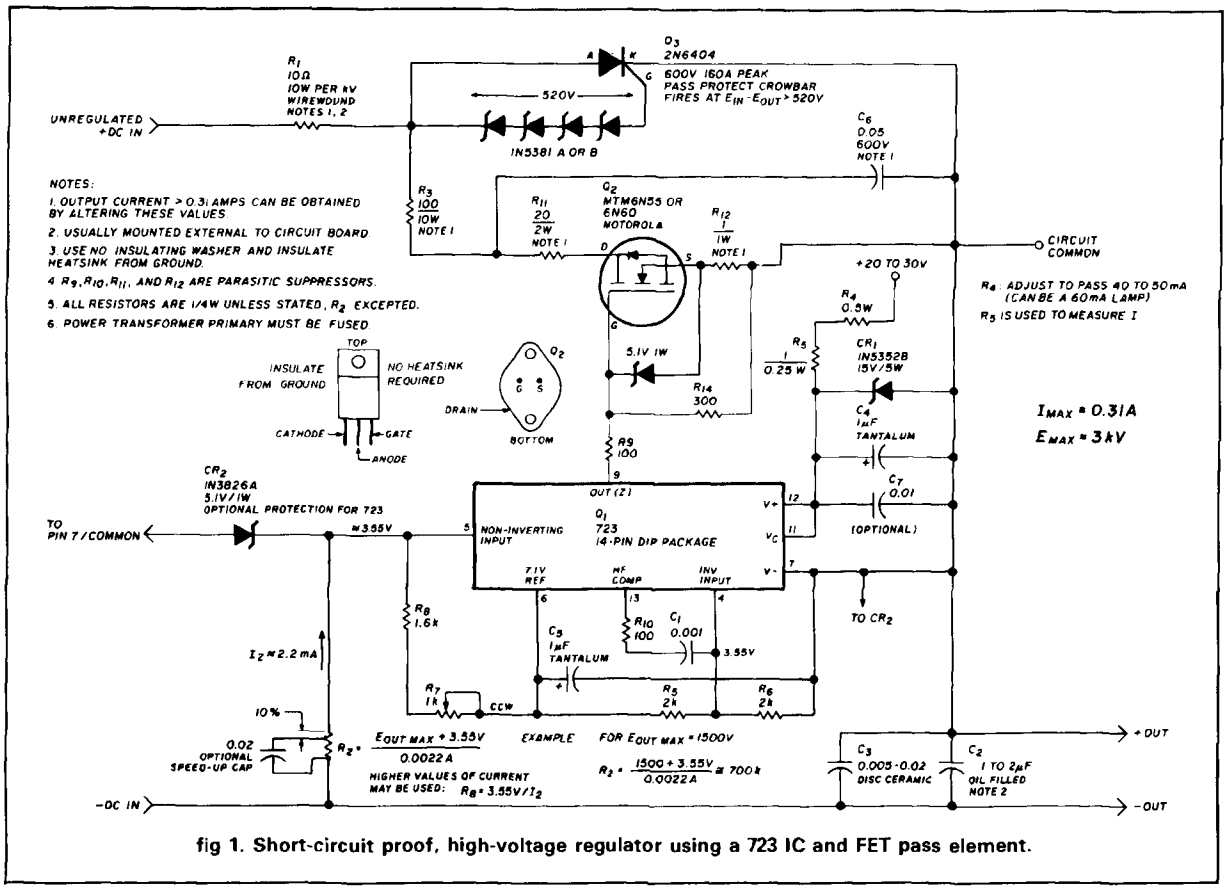


fig 1. Short-circuit proof, high-voltage regulator using a 723 IC and FET pass element.

or 75 watts per device with a heat sink that keeps the FET case below 85 degrees C in a worst-case situation.

The greatest heat dissipation in the pass element usually occurs at about half the maximum current load. At full-load current the unregulated input voltage usually sags, and there is little remaining voltage drop in the pass element. So, even though the current is maximum, the pass voltage drop is minimum, and the heat dissipation is less than maximum.

circuit description

Series-pass regulators work on the principle that regulation will be achieved if they can be made to automatically waste the difference between the varying unregulated input and the desired regulated output voltages. The regulating process is a working example of Kirchoff's Law: The sum of all the voltage drops (the pass voltage plus the output voltage) are equal to the voltage source (the unregulated high-voltage power supply). If more voltage is dropped across the pass element, less voltage is left over for regulated output. If less is dropped across the pass element, the regulated output voltage increases. The missing piece is the brain that tells the pass element's gate what to do.

The circuit's brain is a 723 precision regulator integrated circuit in the upside-down and backward positive floating regulator configuration. In this regulator configuration, the positive output lead is the circuit common, or zero reference. The positive floating regulator uses its own power supply. In this circuit it furnishes about +20 volts at 0.05 A to a 15-volt zener to regulate the voltage that runs the 723 and the negative lead of the 723's supply is connected to (+) circuit common.

If the regulator is operated with the negative output terminal grounded, the 723 regulator, its power supply/transformer, voltage-adjust pot (R_7), and pass FET/heat sink will be elevated to the (+)output voltage. *All elements must be properly insulated from ground.* If the output is operated with the positive lead grounded, only the heat sink need be insulated. More on this later.

The 723 has a temperature compensated 7.1-volt reference, a differential error amplifier, and its own pass transistor. Access to the non-inverting and the inverting input of the differential error amplifier is provided. This gives the circuit designer freedom to create unconventional circuits like the positive floating regulator. 723s are sensitive amplifiers with a vol-

tage gain of about 1000 and an open-loop current gain of about one million.

High gain is essential if a regulator is to accurately sense small deviations in the desired output voltage, make the necessary correction at the gate of the pass transistor, and maintain precise regulated output voltage. It is a problem to keep the regulator regulating and not deregulating by receiving radio signals at the same time. External rf energy allowed to enter a critical terminal on the 723. C_4, C_5, and C_7 are rf bypasses. C_1 and R_{10} reduce the rf gain of the differential amplifier. The input terminals of the differential amplifier are rf-isolated by the resistors that deliver the dc signals. Radio frequency has a hard time passing through high-value resistors.

Several commercial power supplies ignore the RFI problem and let the users figure it out. The 723 gained an undeserved bad reputation from those who did not understand the nature of rf and the amplifying ability of the 723.

current limiting

Most regulated supplies include some form of current limiting. I left it out of this design because the pass FET could not withstand the full, unregulated voltage during a short-circuit/zero voltage output condition. A type of current limiting practical here is a fuse, or circuit breaker, in the *primary* of the HV transformer. Ordinary 3AG fuses should *never* be used in the *secondary* circuit of a high-voltage supply if the fault voltage is above their 250-volt rating. A 3AG fuse acts like an arc lamp instead of a predictable current limiter above 250 volts during a fault, before it eventually explodes.

Fuses are cheap, power FETs are not and are very unforgiving of too much drain-to-source voltage. A crowbar thyristor circuit (Q_2) will automatically fire if the voltage across the FET is close to the breakdown voltage. This protects the FET(s) in this circuit from an unregulated voltage too high for a specific regulated output voltage. It takes about 1.5 μs for Q_2 to fire. During this time, the FET is protected by R_3/C_6, an R/C delay circuit.

If the pass-protect crowbar fires, the output voltage temporarily rises to the same level as that of the unregulated supply. The regulated voltage will return if the load is removed and excessive voltage is lowered. If there is a short across the output, the stored energy from the unregulated supply's filter capacitor is dumped into R_1 for a few milliseconds, until the primary fuse opens. R_1 must be a wire-wound power resistor because the peak dumping current is about 100 amperes.The value of R_1 is increased, as the voltage capability of the supply is increased, to keep the dumping current around 100 amperes. For a 3-kV power supply, R_1 should be a 30-ohm/30-watt unit.

polarity etiquette

Remember that *less positive and more negative* are interchangable terms, as are *less negative and more positive*. For example: +4 volts is more negative, and also less positive, than +5 volts. While −6 volts is more positive than −7 volts, neither voltage is positive with respect to circuit common. The reference "than" is the key.

N channel, enhancement mode, power FET rules

A more positive (than the source) gate voltage makes the FET conduct more heavily. If the gate voltage of the FET becomes less positive/more negative, the conductance of the FET will decrease (like a triode vacuum tube). The gate (control) of a FET resembles the grid in a triode vacuum tube, the source (of current carriers) is like a cathode, and the drain (of current carriers) is like a plate. The big difference between the vacuum tube and the FET is that the FET's control voltage is always positive (usually in the range of +2 to +4 volts) and the (+) gate draws no current — unlike a (+) grid in a vacuum tube.

the 723

The 723 differential error amplifier has two inputs. For the DIP package, Pin 5 is the noninverting input; pin 4 the inverting input. Pin 6, the internal 7.1-volt reference, is passed through a 2:1 voltage divider (R_5/R_6) and the resulting stable 3.55 volts are connected to pin 4, the inverting input. When the system is in balance, 3.5503 volts are applied to the noninverting input by an opposing-polarity voltage divider: R_7, R_8, and the output-voltage sampling resistor R_2. R_7/R_8 connects to the (+) 7.1 volt reference and R_2 connects to the (−) output terminal. If the output voltage is correct the differential error amplifier is balanced, as there is almost no voltage difference between the two input terminals. Therefore, the 723 output is steady and the regulator system is in a state of equilibrium.

Two situations could unbalance the system: too much or too little output voltage. Either situation will develop if the line voltage or the load current changes. A successful regulator must be able to restore balance.

if there is too much (−) output voltage with respect to the (+) common reference

It is safe to assume that the pass FET is conducting too much. The excessive, more negative/less positive output voltage causes more current to flow in R_2. This makes the voltage at the noninverting input more negative than the constant +3.55 volts on the other input. The difference voltage is amplified and the more negative output drives the gate of the pass FET more

negative. This reduces the conductance of the FET, increasing the FET's voltage drop, leaving less voltage for the output and the output voltage decreases to the correct level.

if there is too little (−) output voltage with respect to the (+) common reference

It is safe to assume that the pass FET is not conducting as much as it should.

The *insufficient, less negative/more positive voltage* at the (−) output causes a decrease in current through R_2. This causes the voltage at the noninverting input to also become less negative/more positive than the constant +3.55 volts on the other input. The more positive signal is amplified by 723, driving the gate of the pass FET more positive. This increases the conductance of the FET and lowers the voltage drop across it. Consequently, more voltage is delivered to the output and the output voltage increases to the correct level.

performance

I built a 615 to 1000 volt, 0.31-ampere adjustable power supply observing the following performance parameters. Voltage regulation: ≤ 1 volt change, no load to full load. Ripple and noise: ≤ 150 peak-to-peak mV at 200 mA load, with a 0.02 μF speed-up capacitor across 90 percent of R_2. Without the speed-up capacitor on R_2 peak-to-peak ripple and noise were ≤ 500 mV. Line voltage regulation: ≤ 1 volt change for ± 10 percent line voltage change. These measurements were taken on a Fluke 8022 digital voltmeter and a Hewlet-Packard 1706A oscilloscope.

Changes were made to the regulator circuit and unregulated supply to increase the maximum output voltage to 1900 volts and, with more modifications, to 6100 volts. There was similar performance at the increased voltage levels.

In no case was I able to detect even a one-digit voltage change, from no load to full load, on my Fluke DVM, with its maximum count of 1999.

heat sink caveats

The FET's drain is connected to its case structure. If the case is insulated from the heat sink with a properly installed 1000-volt mica insulating washer, the thermal transfer between the FET and the heat sink will be compromised. It's better to fasten the FET case directly to the heat sink with a thin coating of thermal grease and then insulate it from ground with G10 Fiberglas™, acrylic, or some other nonhygroscopic material. **A high-voltage warning label should be placed on or near it. (We, at *ham radio*, do not recommend having a heat sink at high voltage. If you choose to use this method, provide an obvious label and accord the heat sink the same "respect" you would any other high-voltage component.)**

paralleling FETs

FETs are fast. They oscillate at VHF — just like triode vacuum tubes — unless parasitic suppressor resistors are used at the output and input terminals. Each FET in a bank of paralleled pass FETs should have it's own gate-to-source, charge bleeder resistor; a drain, parasitic *suppressor resistor; a gate*, parasitic suppressor resistor; and a source current equalizing resistor. Mount the suppressor resistors close to the FET(s). The resistor values can be juggled considerably to accommodate different current requirements.

FET selection

A wide range of power FETs are available from Motorola and other manufacturers. For Amateur Radio applications, the Motorola MTM3N95 and the MTM3N100 are probably the most versatile; a 6-kV regulator can be built with either. MTM means it has a standard TO-3 case (now called TO-204). The numeral 3 stands for 3 amperes; the N means that it has an N-type channel, and −) electrons carry the current. The letter P would indicate that it had a P-type channel and that the current carriers were (+) "holes," and all polarities are reversed. The number to the right of the N or P gives the source to drain, maximum voltage rating, less one zero. So, these two devices would handle 950 and 1000 volts, respectively. The rated dissipation on a good heat sink is 125 watts each during a blizzard, or roughly 70 watts indoors.

A good crowbar thyristor (SCR) for protecting a 1000-volt FET is the Motorola MCR225-12 rated at 1000 volts, 300 amperes peak, and ≤ 2μs turn-on time. The series zener trigger for this crowbar can be made from six 150-volt or 160-volt 5-watt zeners. The crowbar-thyristor does not need a heat sink.

resistor R_2 ratings

Resistors have maximum voltage ratings that take precedence over power ratings. Example: A 2-watt, 5.1-megohm composition resistor requires 3193 volts to reach the 2-watt dissipation level. So, although this may look like the right choice for a high-voltage sampling resistor, there is a 500-volt maximum rating that must be observed at all times. Using Ohm's law: $P = E^2/R$; at maximum rating, the "2-watt" resistor should only be used to dissipate 0.049 watts.

Special resistors are available for high voltages. They have a metal oxide, spiral deposited film, but are expensive and hard to find. The 0.5-watt 1 percent variety metal oxide film resistors are easier to locate and have a maximum voltage rating of 350 volts each. You

can place as many as you need in series on a perfboard. I use 100 k, 0.5 watt, 1 percent resistors in series for R_2. They will stand 2.2 mA or 220 volts per unit at 0.5-watt dissipation and cost about eight cents apiece in quantities of 100.

modifications

If necessary, the regulator circuit can be modified to use a different sampling current. However, it probably should not be reduced below 1 mA.

construction

I built the circuit on a piece of perfboard, using a wire-wrap IC socket with the pins bent flat. You can also use a pc board if the traces used to carry the ≥ 100 ampere short-circuit current are made of sufficient cross section.

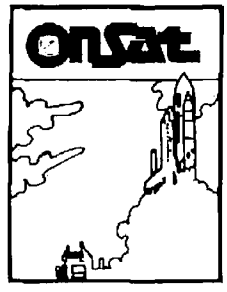
unregulated power supply considerations

Keep in mind that the unregulated voltage needs to be only slightly higher than the full-load, regulated voltage. Extra voltage will be wasted as heat, increasing the burden on the pass element. A wide range high-voltage supply should use a multi tapped power transformer.

ham radio

OnSat®

"America's Weekly Guide to Satellite TV"



The best in satellite programming! Featuring: ★ Over 120 Channels listed ★ Weekly, Updated Listings ★ Magazine Format ★ Complete Alphabetical Movie Listings ★ Sports Specials ★ Prime Time Grids ★ Specials ★Programming Updates!

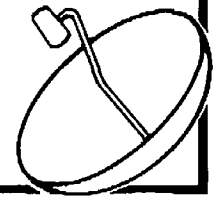
- **Only $45.00 per year (52 weekly issues)**
- **2 Years $79.00 (104 weekly issues)**
- **$1.00 for sample copy**

*NC Residents must add 5% Sales Tax

Subscribe Today!

call toll free 1-800-234-0021
Visa® and MasterCard® accepted

OnSat PO Box 2347 Shelby, NC 28151-2347



W6SAI BOOKS

published by Bill Orr, W6SAI and Stu Cowan, W2LX

BEAM ANTENNA HANDBOOK
Completely revised and updated with the latest computer generated information on BEAM Antenna design. Covers HF and VHF Yagis and 10, 18 and 24 MHz WARC bands. Everything you need to know. 204 illustrations. 268 pages. ©1985. Revised 1st edition.
☐ IRP-BA — Softbound $11.95

SIMPLE LOW-COST WIRE ANTENNAS
Primer on how-to-build simple low cost wire antennas. Includes invisible designs for apartment dwellers. Full of diagrams and schematics. 192 pages. ©1972 2nd edition
☐ IRP-WA — Softbound $11.95

ALL ABOUT CUBICAL QUAD ANTENNAS
Simple to build, lightweight, and high performance make the Quad at DX'ers delight. Everything from the single element to a multi-element monster. A wealth of information on construction, feeding, tuning and installing the quad antenna. 112 pages. ©1982. 3rd edition.
☐ IRP-CQ — Softbound $9.95

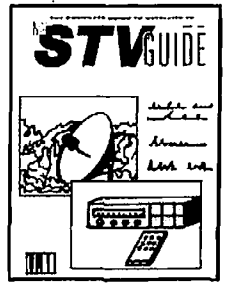
THE RADIO AMATEUR ANTENNA HANDBOOK
A wealth of projects that covers verticals, long wires, beams as well as plenty of other interesting designs. It includes an honest judgement of gain figures, how to site your antenna for the best performance, a look at the Yagi-Quad controversy, baluns, slopers, and delta loops. Practical antenna projects that work! 190 pages. ©1978. 1st edition.
☐ IRP-AH — Softbound $11.95

Please enclose $3.50 for shipping and handling

ham radio magazine BOOKSTORE
GREENVILLE, NH 03048 (603) 878-1441

STV GUIDE

The new **STV Guide** contains valuable information on zoning regulations, scrambling, plus technical tips for installing or updating a satellite system—and now a precise monthly guide to satellite TV with the latest program listings for over **90 channels**!



All this in each complete issue of **STV Guide!**

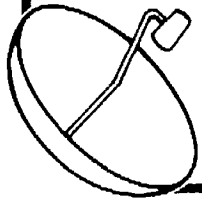
- **Only $48.00 per year (12 monthly issues)**
- **$2.00 for a sample copy**

*NC Residents must add 5% sales tax

Subscribe Today!

Call toll free 1-800-234-0021
Visa® and MasterCard® accepted

STV Guide PO Box 2384 Shelby, NC 28151-2384





ELMER's NOTEBOOK

Tom McMullen, W1SL

propagation basics

One of the great mysteries to most Amateur Radio newcomers is how DX signals get from place to place around the globe. To a casual or uninformed listener, there is no apparent reason for some bands to be "dead" while others are booming with activity. And why does a band full of very strong signals fade out suddenly sometimes, but at other times slowly and incompletely?

There are reasons for this behavior, and an experienced Amateur soon learns to take advantage of the mechanism that provides a path to that distant station.

It all has to do with the ionosphere — that layer of gases that makes up the atmosphere we live, breathe, and fly in. Under the influence of radiation from the sun, this shell that protects life on earth takes on some strange properties that provide life on our Amateur bands.

layer after layer

Fortunately for us, the entire atmosphere does not react in the same way to solar radiation. There are "layers" of reaction at well-defined heights above ground; these layers change their characteristics daily and seasonally. Normal ultraviolet radiation from the sun causes most of the action, with help from periodic outbursts of radiation like Extreme Ultraviolet (EUV) and X-rays, and both high- and low-energy particles.

When ultraviolet and other solar radiation reaches the atmosphere, it reacts with the air molecules in such a way that they become "ionized". Some electrons are knocked loose from their parent atoms, and some molecules gain an extra electron or two. The result is a layer of particles that have an electrical charge, either positive or negative. Such a layer reacts with radio waves as they travel upward from the surface. Layers of different densities occur at different levels in the atmosphere. The lowest layer, approximately 45 to 55 miles above the surface, is called the "D" layer. There is also an "E" layer at about 65 to 75 miles high. It has a wandering cousin called "sporadic E" that creates some interesting conditions. (More about this one later.)

Things get more active at heights of 90 to 250 miles. There are two layers up there, called "F1" and "F2." These have an unusual property in that they are separate, distinct layers during the daylight hours, but combine after sunset to form just one "F" layer. **Figure 1** shows these layers as they might appear during a normal daylight period.

the D layer

This lowest layer is not really of much use to Amateurs. In fact, it usually works against our desire to QSO on the lower frequency bands (1.8, 3.5, and sometimes 7 MHz) by absorbing the waves as they travel outward from the

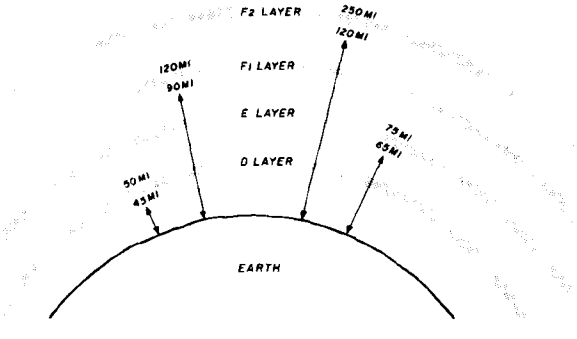


fig. 1. The atmosphere contains layers of ionized atoms at various heights above ground. These layers, D, E, F1, and F2 bend radio waves back to earth. The density of ionization determines the frequencies that are usable; the height determines the distance to the first (and subsequent) point of return to earth. At night the D layer disappears, and F1 and F2 combine to become one F layer.

antenna. The density of the D layer is such that wavelengths below a certain frequency (called the LUF, or Lowest Usable Frequency) are simply absorbed on the way through. Talk about a big dummy load! The D layer dissipates after sunset.

You can hear the effects of this dissipation on the AM broadcast band. Throughout the day, only nearby stations can be heard. But not long after sunset, DX starts to come in at ever increasing distances until you can often tune in stations half a continent away. That's why so many AM broadcast stations have to sign off at sunset — they would create unbelievable QRM when the D layer dissipates and allows better propagation. The same change takes place on the 1.8, 3.5, and 7 MHz bands; the distances that can be worked on 3.5 and 7 can span the globe. Of course, our high-flying friend, the F layer, is what provides all this DX on these lower bands at night.

the F layer(s)

No one is exactly sure why there are two F layers, but they definitely exist. Layer height and density are determined by sending a radio-frequency pulse straight up and recording the reflections as they return; the instrument used is called an *ionosonde*. Not only does this locate the height of the layers, but it can determine the point at which nothing is reflected when the radio frequency of the pulse is varied. This is the Maximum Usable Frequency (MUF). Frequencies higher than this will just keep going out into space, and those between the LUF and MUF will be bent (refracted) so that they return to earth.

The F1 layer seems to have very little to do — just a small amount of refracting except in times of very high solar activity. The F2 layer provides the bending that creates most of the DX openings during the day and most of the night. The density of the F2 layer is directly affected by the sun's activity, and can provide DX signals that vary from being just readable to pinning the S-meter. The higher the activity, the higher the MUF will be. This means that during periods of high solar activity the MUF will often climb up beyond 30 MHz, even reaching above 50 MHz in very good years. We are just starting a period of increasing activity, so get ready now for some spectacular openings on 28 MHz during the next 4 or 5 years. Peaks of activity can't be pinned down precisely, but the peak for this cycle should occur in the early 1990s. After that, there will be a gradual decline to the next minimum. The cycle from high to high (and low to low) runs approximately 11 years.

E and sporadic E

This layer was once called the "Kennely-Heaviside layer" after some early investigators who theorized about its properties. It provides relatively short-hop propagation by bending signals back to a point 600 to 1200 miles away.

Its cousin, "sporadic E" (E_s), is not consistent enough to provide much excitement on the Amateur bands below 21 MHz. Its effects would be masked by F-layer reflection and by noise levels. The E_s layer begins to be evident above 28 MHz when it is active; at 50 and 144 MHz the activity can provide amazingly strong signal paths. E_s signals have often been heard as high as 220 MHz, but it was not until early 1988 that two-way contact was made via this medium at 220 MHz.

The theory of E_s propagation that seems to fit is that it is a "cloud" or "patch" of ionization that wanders erratically about at heights of 65 to 75 miles. The most common locations for these clouds in the United States seem to be the southeastern part of the country. They often start near the Gulf coast in Louisiana or Mississippi, and travel northward toward Arkansas and Missouri. In some instances, a second cloud appears over the southwest. When this happens, VHF enthusiasts can experience the thrill of "double-hop" DX, with contacts possible out to 2,000 miles or more.

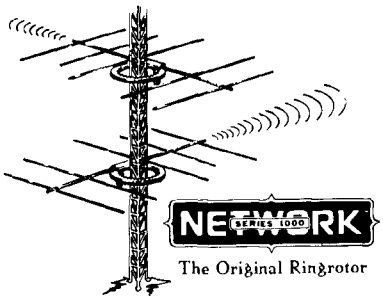
These E_s clouds have appeared farther east and north as well, and there are reports of European E_s propagation on 144 MHz. Signals can be very loud and stay with you for several minutes, or



130



131



Check the advantages to you, the DX'er, by using one or more of our Network Series 1000 Ringrotors:

- ✓ Now possible: 1 tower - **Multiple rotating antennae**
- ✓ Yet retain - **individual rotation**
- ✓ I - Beam ring construction **for strength**
- ✓ 24VDC gearmotor - steel gear drive **for power**
- ✓ 1 degree position feedback **for accuracy**
- ✓ Lower rotor position on tower **for fewer lightning strikes**
- ✓ A serious product **for serious users.**

YOU MAY ORDER NOW BY CALLING

TIC General

P.O. Box 1, 302 E. 3rd
Thief River Falls, MN 56701
Phone: Toll-free 1-800-423-6417
or 218-681-1291

✓ 126

QuickKit G5RV, Loop, & Dipole Kits

Fast & Easy to Build
- Everything included
- Failsafe visual instructions
- No measuring / cutting
- Finish antenna in minutes

Quality Components
- Presoldered Amphenol PL259
- Kinkproof Superflex wire
- Fully insulated, w/s sealed, no-corrode, low noise design

Fastest Antennas In the West!
AntennasWest
(801) 373-8425

- Full Size G5RV dipole coverage 80-10 $34.95
- Half Size G5RV dipole coverage 40-10 $24.95
- Quarter Size G5RV dipole coverage 20-10 $19.95
- Marconi Adapter kit $ 4.95
- Antenna Launcher kit $14.95
- 200' Dacron 250# line $11.95
- Loops, dipoles, feedlines, etc.

Add $5 Shipping & Handling
Catalog $1 by 1st class mail
Dept H, Provo, UT 84603-1144

✓ 112

AMATEUR RADIO MAIL LISTS
Self-stick 1x3 labels
*** NEWLY LICENCED HAMS ***
*** ALL NEW UPGRADES ***
*** UPDATED EACH WEEK ***
Total List = 462,728 (ZIP sorted)
Price is 2.5 cents each (4-up Cheshire)
BUCKMASTER PUBLISHING
Mineral, Virginia 23117
703-894-5777
800-282-5628

✓ 127

TELL YOUR FRIENDS
about
ham radio

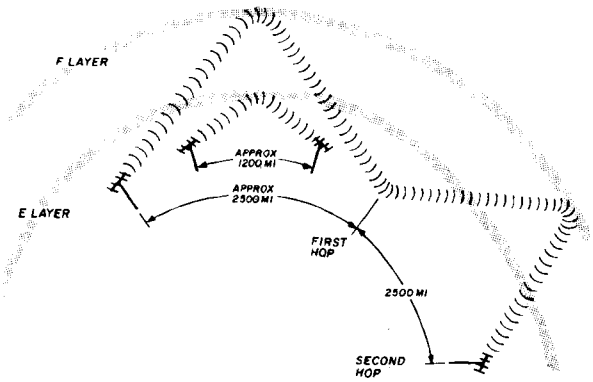


fig. 2. ionized layers bend radio waves back to earth at distances depending on their height. Waves reflected from the ground can re-enter the atmosphere to be returned again for multiple-hop DX paths.

they can disappear in the middle of a QSO. In E_S QSOs it's wise to trade vital information first (QTH, signal strength, name, etc.), then chat about other things before the signal drops out. The points of reflection seem to move rapidly, and this creates somewhat of a contest atmosphere for the VHF enthusiast. The game is to see how many stations you can work before the cloud dissipates.

short path, long path

Another quirk of the F2 layer is its ability to fool us by not taking the shortest path between two points. Stations that are 6,000 miles apart, for instance, can sometimes work each other by pointing their antennas in the opposite direction for a path length of 18,000 miles. This happens because the amount of ionization can sometimes be greater in that direction than over the shorter path, or the short path may be noisy or have high absorption. Follow this procedure: if you feel that a path should be open but you're not hearing anything in that direction, turn your antenna around 180 degrees and try the other way. It often works surprisingly well.

multihop propagation

It doesn't take a great mathematician to figure out that a layer only 170 to 250 miles high can't reflect a radio wave to a point on the other side of the globe. In order to be line-of-sight at both ends of the path, the layer would have to be almost as high as the moon. As things work out, the radio energy returned to earth from the F2 (or other) layer strikes the ground and is reflected skyward again, to be bent back to reach the ground a second time or more (see **fig. 2**). Each time it does this, some signal strength is lost, but there's usually enough left for a solid QSO.

"Backscatter" is another interesting happening. In this mode, a signal strikes the ground at the end of the first hop, and enough of it is scattered back in the same direction to produce a signal near the starting point. On 28 MHz, for example, you might hear a station 100 or so miles away when you are both trying to work stations to the west, but if you turn your beam in his direction, you don't hear the signal. Backscatter signals are usually not very strong, but QSOs have been made this way. Sometimes this is the only way to get nearby contacts for a Worked All States (WAS) certificate.

the "greyline"

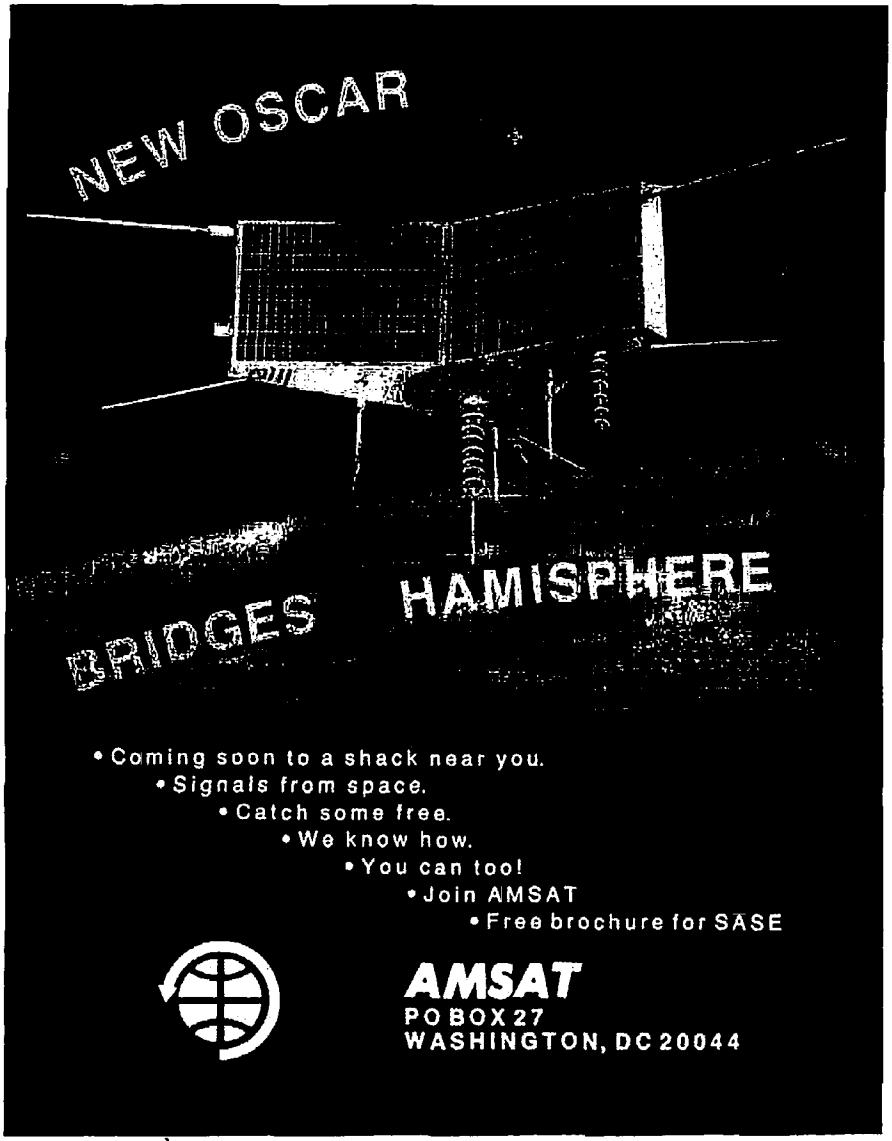
A mode that many Amateurs are learning to appreciate is the "greyline DX path." This is a band of good propagation that follows the twilight zone around the world. If you are in the twilight area just after sunset, chances are very good that you can work someone who is in a similar zone just before sunrise at his location. The opposite is also true — as long as both of you are in

this "edge-of-night" area, a good path can exist in between. At the spring and fall equinoxes the path will be directly over the poles; at other times the path will be off several degrees from north or south because of the earth's tilt. Propagation is possible because there is still enough F-layer activity to bend the signals, but the D layer has not built up enough to absorb them. There are computer programs that help find locations in the greyline at different times of year.

There are many other modes of propagation that help us make QSOs on various frequencies and at varying distances. Those I've outlined are responsible for 99 percent of all DX QSOs. Many articles and books have been written about the ionosphere and its effects on radio propagation, and some are fascinating reading. A serious DXer will learn all he can about this tool and use it for greater achievements. The rest of us can simply listen and learn to be at the right frequency at the right time by developing our own feel for openings. The column by Garth Stonehocker, KØRYW, in this magazine is a great help. Also, you can learn to eavesdrop on the sun's activity by tuning in WWV and using their sunspot and solar activity information.

However you go about it, DXing is great fun (and often contagious). Enjoy!

ham radio



119

CADDELL COIL CORP.

35 Main Street
Poultney, VT 05764
802-287-4055

BALUNS

Get POWER to your antenna! Our Baluns are already wound and ready for installation in your transmatch or you may enclose them in a weatherproof box and connect them directly at the antenna. They are designed for 3-30 MHz operation. (See ARRL Handbook pages 19-9 or 6-20 for construction details.)

100 Watt (4:1, 6:1, 9:1, or 1:1 impedance—select one)	$10.50
Universal Transmatch 1 KW (4:1 impedance)	14.50
Universal Transmatch 2 KW (4:1 impedance)	17.00
Universal Transmatch 1 KW (6:1, 9:1, or 1:1—select one)	16.00
Universal Transmatch 2 KW (6:1, 9:1, or 1:1—select one)	18.50

Please send large SASE for info.

TEXPRO snap -on- choke



ELIMINATES RF INTERFERENCE IN: TV sets, Radios, HI-FI, PA systems, Telephones, VCRs, Test equipment, Burglar and Fire alarms, Modems, Monitors, Computers, Radio and TV stations, etc.

EASY TO USE: fits over and snaps onto small, large and ribbon cables. No need to rewire connectors. Unique, split ferrite core design fits up to RG8U coax cables.

WORKS IN "COMMON MODE", filters current induced in the braid of shielded cables and ground wires!

Special ferrite material effective 0.5 - 200 MHz.

DOES NOT VOID EQUIPMENT WARRANTY

Available from your dealer or order direct from:

computeradio
Box 282, Pine Brook, NJ 07058
Tel: (201) 227-0712

Package of 4 chokes with inst. instructions
$12.99
+ $2.00 shipping

Send personal check with order, we ship same day First Class. 30-day money back warranty. Quantity discounts.

120

THE SOTRON
COMPACT ANTENNAS FROM 160-10 METERS

NO TUNERS!
NO RADIALS!
NO RESISTORS!
NO COMPROMISE!

THREE EXCELLENT REVIEWS JUST DON'T HAPPEN BY CHANCE.
CALL US FOR A FREE CATALOGUE.

*See review in Oct 73, 1984
*Sept 73, 1985 *March 73, 1986

NEW LOCATION!
BILAL COMPANY
137 Manchester Dr.
Florissant, Colo. 80816
(719) 687-0650

121



DX FORECASTER

Garth Stonehocker, K0RYW

summer signal levels

With the summer sunshine and warmer weather comes the annual decrease in signals levels.

Signal strength is lost as its energy travels away from the transmitter. The largest loss is called free space loss, and it decreases all signals with distance. The amount of additional loss depends on the transmission mode and signal origin conditions. Examples of modes are: groundwave, line of sight, and skywave. Two originating conditions are launch angle and polarization of the launch from the antenna. For hf skywave propagation the losses of the ionospheric transit, its reflection, and the ground reflection in between hops must be included.

Most ionospheric loss comes from signal energy colliding with ions on its path through the D region, 60-80 miles (100-120 km) above the earth. The level of energy absorbed per transit of the D region depends on the location of the sun and is a function of cosine X, the zenith angle to the sun. Maximum absorption occurs at the subsolar point, directly under the sun; absorption decreases as the signal path moves away from the subsolar point in any direction. It is the next largest signal loss — 10 to 30 dB between night and day on midlatitude one-hop paths. Seasonal absorption in the D region increases as the sun's subsolar point moves to 23 degrees north for the United States' summer. This seasonal loss can amount to 18 dB more in summer than winter for midlatitude single hops. Absorption in the D region changes about 8 dB for a one-hop midlatitude path between sunspot numbers 20 and 120 during the 11-year sunspot cycle. It is rising fast this year.

The statistics above are given for the one-hop path as it is the easiest in which to see changes. When the signal travels three or more hops, the changes get blurred between them. There is more absorption with a larger number of hops, but the effect of absorption per hop is not linearly additive. Multiple hops cross into the night for the winter hemisphere, blurring additional losses. Ground reflections between hops are also lossy; loss varies with ground roughness and conductivity. On the average this loss is around 5 dB. All together, the losses amount to 120 dB of signal loss of transmitted power when received on summer days. Absorption is inversely proportional to frequency. However, this frequency dependency is hard to assess because as the frequency changes so does the extent of layer penetration. As a rough estimate, 10-MHz signals tend to incur twice as much signal absorption as 20-MHz signals.

What can DXers do to enhance their effectiveness during summertime operations? Review the chart on the next page for the highest band available to the DX area you wish to contact. Operate during the evening, taking advantage of its lower absorption, but before the maximum usable frequency drops off. Make sure your antenna radiates substantial energy at that low TOA for the best chance of contacting the desired DX station. Keep up on current conditions (in terms of signal absorption and variability, QSB) by listening to radio station WWV on 5, 10, and 15 MHz at 18 minutes after the hour. If the solar flux has just increasd, absorption will be above normal. Absorption and fading conditions (QSB) are associated with an A figure of greater than 15 or a K figure greater than 4.

last-minute forecast

Higher frequency DX bands will have the most and longest long-skip openings in the first week or so of August (because of expected higher solar flux) and again the last week. Short-skip sporadic E openings will also be available, but spread out through the month and emphasizing different times of day between the higher and lower bands. The lower bands should be best the third week due to the expected lower solar flux; lower absorption during the day affects daytime short skip and creates better nighttime signals toward sunrise and sunset. Expect some disturbances 1 to 2 days long, 1 to 2 days after solar flares are announced over WWV. These disturbances will be more likely July 29th-August 1st, August 4-6th, and 24-27th. The VHF/UHF enthusiast will note that the moon's perigee and the full moon appears on the 27th. The Perseids meteor shower will occur from the 10th to the 14th, with a maximum rate of better than 50 meteors per hour expected on the 11th and 12th. This is an excellent shower to work with for meteor burst.

band-by-band summary

Six-meter paths will open for a half hour to a couple of hours some days around local noon. Sporadic E propagation will make this short-skip path possible out to nearly 1200 miles (2000 km) per hop.

Ten and 15 meters will have a few short-skip E_s openings and some long-skip openings to southern areas of the world during daylight. Some transequatorial (TE) openings associated with mildly disturbed geomagnetic-ionospheric conditions may occur in the evening hours toward the end of the month.

Twenty and 30 meters will support DX propagation from most areas of the world during daylight and into the evening, with a lengthened skip out to 2000 miles (3000 km) per hop. The amount of daylight is still near the maximum, providing many hours of good DXing.

Thirty, 40, 80, and 160 meters are the night DXer's bands. On many nights 30 or 40 meters will be the only usable bands because of thunderstorm QRN, but signal strengths via E_s short skip may overcome the static, when E_s is available. Try the predawn hours for less QRN.

ham radio

AUGUST

GMT	PDT	WESTERN USA N	NE	E	SE	S	SW	W	NW
0000	5:00	20	20	20	12	15	12	10	15
0100	6:00	20	*30*	20	12	20	10	10	15
0200	7:00	15	*30*	*20*	15	20	10	10	15
0300	0:00	15	*30*	*20*	15	20	10	10	12
0400	9:00	20	*30*	*20*	20*	20	12	12	15
0500	10:00	20	*20*	*20*	20	30	12	12	15
0600	11:00	20	20	15	20	30	12	12	15
0700	12:00	20	20	15	*20*	30	15	15	15
0800	1:00	20	*30*	15	*20*	30	15	15	20
0900	2:00	*20*	*30*	20	*20*	*30*	15	15	20
1000	3:00	*30*	20	20	*20*	*30*	20	20	20
1100	4:00	*30*	20	20	*20*	*30*	*20*	20	20
1200	5:00	*20*	20	15	20	*30*	*20*	20	*20*
1300	6:00	20	20	15	20	*30*	*20*	*20*	*20*
1400	7:00	20	20	12	15	*30*	*20*	*30*	*20*
1500	8:00	20	15	12	15	*30*	*20*	*30*	*30*
1600	9:00	20	15	10	12	*30*	*20*	*30*	*30*
1700	10:00	20	15	10	12	20	20	*30*	*30*
1800	11:00	*20*	15*	12	12	20	15	15	*30*
1900	12:00	*30*	15	15	10	20	15	15	20
2000	1:00	*30*	15	15	10	20	12	12	20
2100	2:00	20	20	15	10	15	12	12	20
2200	3:00	20	20	20	10	15	12	12	20
2300	4:00	20	20	20	10	15	12	10	15

	MDT	MID USA N	NE	E	SE	S	SW	W	NW	CDT
	6:00	20	20	20	12	15	10	10	15	7:00
	7:00	20	20	20	12	20	10	10	15	8:00
	8:00	20*	*30*	20	15	20	10	10	15	9:00
	9:00	20*	*30*	*20*	15	20	12	12	15	10:00
	10:00	20*	*30*	*20*	15	20	12	12	20	11:00
	11:00	20	*30*	*20*	20	30	12	12	20	12:00
	12:00	20	*20*	*20*	20	30	15	15	20	1:00
	1:00	20	*30*	20	*20*	30	15	15	20	2:00
	2:00	*20*	20	20	*20*	30	15	15	20	3:00
	3:00	*30*	20	*20*	*20*	30	20	15	20	4:00
	4:00	*30*	20	15	*20*	*30*	20	20	*20*	5:00
	5:00	20	20	15	*20*	*30*	20	20	*20*	6:00
	6:00	20*	20	12	20	*30*	*20*	*20*	*20*	7:00
	7:00	20*	15	12	20	*30*	*20*	*20*	20	8:00
	8:00	20*	15	12	15	*30*	*20*	*20*	20	9:00
	9:00	20	15	10	15	*30*	*20*	*30*	*20*	10:00
	10:00	20	15	10	15	*30*	*20*	*30*	*20*	11:00
	11:00	20	15	10	12	20	20	*20*	*20*	12:00
	12:00	20	15	12	12	20	15	15	20	1:00
	1:00	*30*	20	12	12	20	15	15	20	2:00
	2:00	*30*	20	12	10	20	15	12	20	3:00
	3:00	*30*	20	15	10	20	12	12	20	4:00
	4:00	20	20	15	10	15	12	12	15	5:00
	5:00	20	20	20	10	15	12	10	15	6:00

	EDT	EASTERN USA N	NE	E	SE	S	SW	W	NW
	8:00	20	20	20	12	15	10	10	15
	9:00	20	20	20	12	15	10	10	15
	10:00	20	20	20	15	20	12	10	15
	11:00	20	*30*	*20*	15	20	12	12	15
	12:00	20	*30*	*20*	15	20	12	12	20
	1:00	20	*30*	*20*	20	30	15	12	20
	2:00	*20*	*30*	*20*	20	30	15	15	20
	3:00	*30*	*30*	20	*20*	30	15	15	20
	4:00	*30*	*20*	20	*20*	30	20	15	*20*
	5:00	20	20	*20*	*20*	30	20	20	*20*
	6:00	20	20	15	*20*	30	*20*	20	*20*
	7:00	20	20	15	20	30	*20*	*20*	20
	8:00	20*	20	12	20	30	*20*	*20*	20
	9:00	20*	20	12	15	30	*20*	*20*	20
	10:00	20*	20*	12	15	30	*20*	*20*	20
	11:00	20	15	10	15	30	*20*	*20*	*20*
	12:00	20	15	10	12	30	20	*20*	*20*
	1:00	20	15	10	12	20	15	15	*20*
	2:00	20	15	12	10	20	15	15	20
	3:00	*30*	20*	12	10	20	15	15	20
	4:00	*30*	20	15	10	20	12	12	20
	5:00	*30*	20	15	10	20	12	12	15
	6:00	20	20	20	10	20	12	12	15
	7:00	20	20	20	12	15	10	10	15

	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
	ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next higher band for possible openings.

2x4Z BASE REPEATER ANTENNA

THE HIGHEST GAIN DUAL BAND BASE/REPEATER ANTENNA

HIGH POWER 200 WATTS

CENTER FREQUENCY
146.500 MHz
446.500 MHz

GAIN:
VHF - 8.2dB
UHF - 11.5dB
VSWR - 1.-1.2 or less

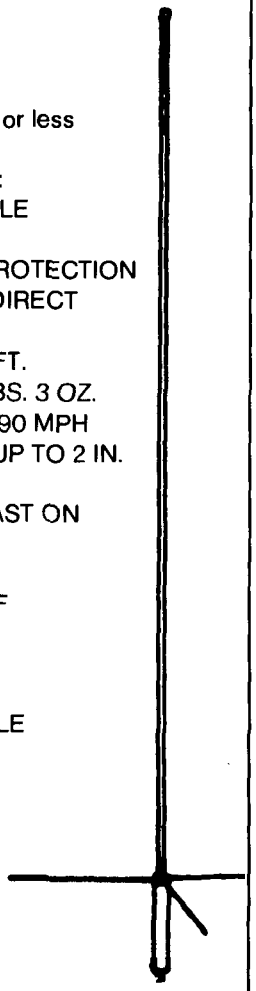
CONNECTOR:
N TYPE FEMALE

LIGHTNING PROTECTION
GROUNDED DIRECT

LENGTH: 16 FT.
WEIGHT: 5 LBS. 3 OZ.
WIND LOAD: 90 MPH
MOUNTING: UP TO 2 IN. MAST
CAN SIMULCAST ON BOTH BANDS

WATERPROOF CONNECTING JOINTS

UPS SHIPPABLE



AMATEUR SPECIAL

NCG

1275 NORTH GROVE ST.
ANAHEIM, CALIF. 92806
(714) 630-4541
CABLE: NATCOLGLZ
FAX (714) 630-7024

104

(continued from page 9)

cient associated with a teenager asking his parents to finance a new transceiver!

A comprehensive market survey would reveal that not all hams are affluent enough to afford such luxuries as $6,000 transceivers. The active-Amateur statistics clearly indicate that a large portion of the fraternity consists of retirees who must exist on fixed incomes. A properly equipped, modern Amateur station is frequently beyond their means. Although I am semi-retired, and am not by any means destitute, I rebel against the cost of the new Amateur equipment. I have countless associates who share this sentiment. This represents an untapped market. An astute manufacturer would recognize this vast potential.

What has been needed in the United States for a long time is a no-frills transceiver. It should have a quality design for CW and SSB operation. A maximum output power of 100 watts is adequate. It would not contain a speech processor, i-f shift or width circuit, nor would it need to have computer interface capability. A noise blanker is by no means a necessity, since most blankers are ineffective for the more common types of QRN, and they degrade the receiver dynamic range when activated. I also question whether or not a basic rig needs memory channels and two internal VFOs. Getting rid of the frills can bring the price of a good transceiver within the reach of those who can't, or don't, wish to invest several thousands of dollars in a hobby they use one or two days a week.

Joe nibbled at the edges of the problem in his HR editorial. I admire his tact and understand his limitations. But, someone needs to take the initiative toward encouraging the United States and foreign manufacturers to develop a *practical* transceiver that can serve our basic operating needs — especially those of the Novice and other new Amateurs. If a fancier rig is desired later on, rest assured they will buy it. But for now we need to get them started with the minimum of economic stress. What ever happened to the concept of high volumne and reduced per-unit-profit (shades of Henry Ford)? Small volume and high markup is not in the best interests of Amateur Radio.

Doug DeMaw, **W1FB**, Luther, **Michigan 49656**

generation gap in Amateur Radio

Dear HR:

Your editorial in the June issue reminded me of a similar request by Rich Rosen, regarding how to make Amateur Radio more accomodating and attractive. I remember some of the replies, both appropriate and absurd. At that time, the respondents felt that 1) it was up to the FCC to make it easier to obtain licenses, 2) the equipment manufacturers were not supplying sophisticated or inexpensive enough gear, 3) the technical challenges for Amateur Radio were diminishing, 4) there was an insufficient number of contests and prizes. The list went on.

I believe that Amateur Radio is experiencing the same phenomena that affects the entire country: a generation gap. Yes, I know that term is outdated but the application is here. The country has two (or more) generations of "wanna-bes" and "gimmes". Working couples spend more and more time away from home to provide more and more for their families. Their offspring are accustomed to essentially getting everything that they want.

Amateur Radio has and always will provide the kinds of challenges that people desire. I can't really fault anyone or anything for the decreasing number of ham operators. Society is changing rapidly. Societal expectations are changing just as quickly. Ham radio presents a kind of stable environment. I believe we are all caught up in changes, whether or not we like it or know it.

I would appreciate your printing this letter, and I encourage responses from the readers.

Larry Caracciolo, N3CCW

flea market

RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance**. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

HAM RADIO FREEBIE. On a space available basis, we are going to offer you, our subscriber, a chance to sell your old, used equipment. Please send us a short description of what you want to sell along with price, name, address and phone number. We will run it once in the next available issue of HR. Please limit your ad to 20 words or less.

SALE COLLINS. 75S-3B, 32S-3 rec, trans P/S $700. 30S-1, linear, $1500 *mint*. Z-100/PC, 768k $600. Swan 350 P/S $250. Rich (516) 957-6308 nights.

WANTED: Smith Chart transmission line calculator made and sold by Ham Radio. W8VLN, 1328 East Main, Eaton, OH 45320.

MACINTOSH SATELLITE Tracking and Propagation Software. MacTrak™ displays graphic maps (rectangular, polar, great circle), views from space, schedules, windows. Also tracks Sun and Moon. Compatible with KLM/MIRAGE rotor interface. Shows gray line, sunrise/sunset, bearing/distrnac,e mUF vs time, areas of world "open". SASE for info or $49.95 from R. Stegemeyer, PO Box 1590, Port Orchard, WA 98366.

TEKTRONIX 547 Oscilloscope, 50 MHz-BP $135, Tek-1A1 $60, Tek-1A4 $120, Tek-1L30 Spectrum Analyzer, 0.9-10.5 GHz $350, Hewlett-Packard 606A Signal Generator, 0.05-65 MHz, $100k, HP-8708A Synchronizer $150, HP-3300A Function Generator $95, HP-686C Sweep Generator, 8-12 GHz $95, HP-9865A Cassette Memory $95. Lambda LB-701-FMOV Variable Regulated Power Supply, 300 amps, new $295. A. Emerald, 8956 Swallow, Fountain Valley, CA 92708. (714) 962-5940.

HALL ELECTRONICS buys radio broadcast equipment for cash! Jon Hall, WB4MMV, PO Box 7732, Charlottesville, VA 22906. I804I 973-8697.

CUSTOM EMBROIDERED EMBLEMS, & Enameled Pins, your design, excellent quality, low prices, free booklet. **A.T.** PATCH CO, Box 682 Dept 19, Littleton, NH 03561. (603) 444-3423).

BM-PC RTTY/CW. New CompRtty II *is the complete* RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

HAMLOG COMPUTER PROORAMS. Full features. 17 modules, auto-logs, 7-band WAS/DXCC. Apple $19.96, IBM or CP/M, KAYPRO, Tandy, C128 $24.96. HR-KA1AWH, POB 2015, Peabody, MA 01960.

IAMBIC KEYER Low cost, low-current-drain. Designed by Paul Newland, AD7I. Features dot and dash memory, side tone generator and key circuit current amplifier. Although the sidetone generator and keyer amplifier were touted as options in the article, the kit includes both of these functions. For Kit, order # 151-KIT $19.95. For Assembled board order #151-ASY $29.95. Add $2.50 shipping per order. Calif. residents add 6% sales tax. Visa & M/C accepted. A&A ENGINEERING, 2521 W. LaPalma #K, Anaheim, CA 92801 (714) 952-2114. For circuit details, see June 88 QST.

HARK-RADIO ARCHIVES Non-profit, low income newsletter for youth/elderly. $1 each. $6 bimonthly. 2308 Garfield *#304, Mpls, MN 55405.*

DIGITAL AUTOMATIC DISPLAYS. All Radios. GRAND SYSTEMS, POB 2171, Blaine, Washington 98230.

CHASSIS & CABINTS KITS. SASE. K3IWK, 5120 Harmony Grove Rd, Dover, PA 17315.

COMMODORE/AMIGA CUSTOM CHIPS very inexpensive. (eq. PLA/82S100-$13.25). Diagnostics and other hard to get items. New Heavy Duty Power Supply for the C64-$27.95 plus UPS. Send for complete catalog. KASARA, INC, 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-642-7634, 1-800-248-2983 (outside NY) or 914-356-3131.

WANTED military surplus radio equipment, we need, ARC-164, ARC-114, ARCj-115, ARC-159, ARC-186, ARN-118, RTj-1159A, Collins 718U-5, 719A, top dollar paid or trade for new Amateur gear. Write or phone Bill Slep (704) 524-7519. SLEP ELECTRONICS COMPANY, Highway 441, Otto, NC 28763.

HAMS-HELP. Handicapped Ham needs working HF rig with 10 meters, reasonably priced. Please help. Clem, KA3OUE. Call any time (412) 531-7443 EST.

CLOSED CIRCUIT TELEVISION EQUIPMENT. Discount pricing on cameras, monitors, sequential switches, pan tilt units, etc. Expert design assistance available. Dan Marshall, DETECTION DYNAMICS, 4700 Loyola Lane, #119, Austin, Texas 78723. (512) 345-8401.

WANTED: Operating and/or Maintenance Manual for the Gonset Model G-66B receiver. WE6N, 644 11th Avenue, Coos Bay, OR 97420-4405.

AN-PRC-64 military radio wanted. Will pay top dollar for a unit in very good condition. KC1EZ, Tim McInerney, 316 West 75th Street, New York, NY 10023 (212) 874-3333.

HRs 1970-79, plus 6 early issues, $170 plus shipping. Ned, W1RAN (203) 447-1255 after 5 PM.

SELL: Drake TR-3 HF Xcvr, AC-4 Pwr supply, mic, spkr, swr. Mint condition with manuals. $250. Will ship. Rob, KE8JH, evenings (616) 327-2142.

WANT COLLINS KWM 2/A and accessories. Also looking for other Collins gear. Call after 4 PM EDST (201) 728-7938.

CALL SIGN BADGES: Custom license plate holders. Personal, distinctive. Club discounts. SASE. WB3GND, Box 750, Clinton, MD 20735. (301) 248-7302.

ANALOG AND RF CONSULTING for the San Francisco Bay area. Commercial and military circuits and systems. James Long, Ph.D., N6YB (408) 733-8329.

RTTY JOURNAL—Now in our 36th year. Read about RTTY, AMTOR, PACKET, MSO'S, RTTY CONTESTING, RTTY DX and much more. Year's subscription to RTTY JOURNAL $10.00, foreign slightly higher. Order from: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

MARCO: Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc) invited to join. Presently over 560 members. For information write MARCO, Box 73's, Acme, PA 15610.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224. (213) 774-1255.

DIGITAL AUTOMATIC DISPLAYS. All Radios. GRAND SYSTEMS, POB 2171, Blaine, Washington 98230.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC, ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

VIRGINIA: August 7. The 38th annual Winchester Hamfest, sponsored by the Shenandoah Valley ARC, Clarke County Ruritan Fairgrounds, Rt 7, 2 miles west of Berryville. 7 AM—3 PM. Admission $4. Children under 12 and wives free. Tailgaters and tables $5. License exams. Talk in on 146,22/.82 and .52. For information Joanne Blaker, WB2CMV (703) 869-4878 or write SVARC, POB 139, Winchester, VA 22601.

PENNSYLVANIA: August 7. The 51st Hamfest of the South Hills Brass Pounders and Modulators ARC of Pittsburgh, south campus of Community College of Allegheny County, West Mifflin. Outdoor/indoor flea market, forums. Talk in on 146.13/73 and 146.52. For information Doug Wilson, WA3ZNP, 185 Orchard Avenue, Emsworth, PA 15202.

NEW YORK: August 20. 7th annual Finger Lakes Hamfest. Sponsored by the Tompkins County ARC. New Location—4-H Acres of Rt 13 NE of Ithaca. Donation $3. Flea market space $1. Wheelchair accessible. Free overnight camping. Talk in on 37/97 or 52. For information contact the Kings, N2GFW or N2GFX, Box 227, Etna, NY 13062. (607I 347-4313.

INDIANA: August 7. The Porter County ARC's annual Northwest Indiana Hamfest & Computer Fair, Porter County Fairgrounds & Expo Center, Rt 49, east of Valparaiso. 7 AM. 6 AM vendors. General admission $3.50, under 12 free. Walk-in license exams 8 -10 AM all classes. Talk in on 146.775/175 or 146.52. For information Jamie Veiner, NS9A, POB 1782, Valparaiso, IN 48384.

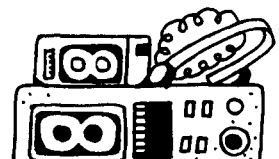
INDIANA: August 7. Angola Hamfest and FM Picnic, Steuben County 4-H Park on Crooked Lake. Gates open 7 AM. Indoor/outdoor spaces. Talk in on 147.21. For information Steuben County Radio Amateurs, POB 252, Angola, IN 46703.

MINNESOTA: August 14. The St. Cloud ARC's Hamfest, Whitney Senior Center in St. Cloud. Ticket donation $3.00. Extra ticket $2.00. Talk in on 34/94 primary, 615-015 sec. Contact: SCARC, Box 141, St. Cloud, MN 56302.

NEVADA: August 20. The combined radio clubs of Reno are sponsoring Reno Hamfest '88, California Building, Idlewild Park. 9 AM to 5 PM. Admission $3. Swap tables $7. License exams, Ham swap, refreshments. Talk in on 146.61 and 147.30+. For information, registration and VE exam SASE to Curley Silva, K7HRW, 3780 Hummingbird Drive, Reno, NV 89506.

TENNESSEE: August 28. The Lebanon Hamfest sponsored by the Short Mountain Repeater Club, Cedars of Lebanon State Park, US 231, 7 miles south of Lebanon. Outdoors only. Bring own tables. Talk in on 146.31-146,91. For information MaryAlice Fanning, KA4GSB, 4936 Danby Drive, Nashville, TN 37211.

MISSOURI: August 28. The St. Charles ARC will sponsor Hamfest 88, Blanchette Park, St. Charles. 6:30 AM-2:30 PM. Free admission and parking. License exams. Handicapped parking. Tailgating $2/space. Talk in on 146.07/67 rep and 146.52. Contact Eric Koch, NF0Q, 2805 Westminister, St. Charles, MO 63301. (314) 946-0948.



OPERATING EVENTS

"Things to do . . ."

Littleton, Colorado: August 21. The Arapahoe Radio Club's annual "Fourteener"s expedition operating from 14,000-ft mountain peaks in the Colorado Rockies. Listen for CQ 14. For certificate send QSL and legal SASE to K9AY, 7277 S. Clermont Drive, Littleton, CO 80122.

HAM RAOIO TODAY has joined the programming lineup from the Voice of the Andes, HCJB Radio, an international broadcasting station that has been operating from Quito, Ecuador since 1931. Programming includes news from all over the world, construction hints, propagation news, equipment reviews and much more. For more information contact John E. Beck, Producer, HAM RADIO TODAY, c/o HCJB Radio, Box 691, Quito, Ecuador, SA.

SEPTEMBER 1988 $2.50

FLASH
220-222 MHz
LOST!
SEE Page 4

HAM RADIO

A Direct Digital Synthesis VFO

The Weekender:
An easy-to-build NiCd pulse charger
Processor for code tapes

Plus...
All your favorite columnists, Ham Notes, and more!



HAM RADIO

SEPTEMBER 1988

volume 21, number 9

T. H. Tenney, Jr., W1NLB
publisher
and editor-in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
production editor

Peggy Tenney, KA1ODG
copy editor

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Henry S. Gallup, KA1RYG
advertising sales manager

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Phil Alix, N1FPX
traffic manager

Maribeth Buchanan
HAM RADIO Bookstore

Hans Evers, PA0CX
cover

HAM RADIO Magazine is published monthly by Communications Technology, Inc. Greenville, New Hampshire 03048-0498 Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail),
one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 109

Microfilm copies are available from Buckmaster Publishing Mineral, Virginia 23117

Cassette tapes of selected articles from *HAM RADIO* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1988 by Communications Technology, Inc
Title registered at U.S. Patent Office

Second-class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *HAM RADIO*
Greenville, New Hampshire 03048-0498

FEATURES

10 Direct Synthesis VFO
Robert J. Zavrel, Jr., W7SX

18 The Weekender: An Easy-to-Build NiCd Pulse Charger
R.L. Measures, AG6K

22 Measuring Transmission Line Parameters
A.E. Popodi, OE2APM/AA3K

31 Great Circle Computations Using Lotus 1-2-3
Thomas M. Hart, AD1B

42 A DTMF Tone Signaling Circuit
Michael S.R. Moore, WV6A

53 VHF/UHF World: Loose Ends
Joe Reisert, W1JR

61 The Weekender: Processor for Code Tapes
Andy Griffith, W4ULD

65 Tuning Indicator for RTTY and Packet Radio
Bruce L. Meyer, WØHZR

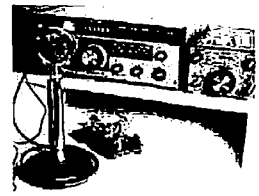
76 A Five-band Dipole
Fred Brown, W6HPH

82 Radiotelegraph Codes: There's Not Just One
W. Clem Small, KR6A

84 Add a Digital Readout to the "Poor Man's Spectrum Analyzer"
Murray Barlowe, WA2PZO

95 7/8-inch Hardline Coax Connectors Construct at Your Own Low Cost
John M. Mathis, M.D., WA5FAC

98 Construction Techniques Using PVC Pipe to Make Antennas
Van R. Field, W2OQI



W7SX, Page 10



Ham Notebook, Page 38

DEPARTMENTS

Publisher's Log	4	DX Forecaster	104
Backscatter	6	Ham Mart	108
Comments	9	Elmer's Notebook	110
Ham Radio Techniques	26	Flea Market	114
Practically Speaking	34	Advertiser's Index	116
Ham Notebook	38	Reader Service	116
New Products	48,56,100		



FLASH FCC TAKES 220-222 MHz!

On Thursday August 4, the FCC announced its reallocation of 220-222 MHz to the Land Mobile Service. Despite overwhelming opposition from industry, government agencies and Amateurs, the three sitting commissioners concluded unanimously that the reallocation was in the "public interest." The ARRL immediately filed a Petition for Reconsideration and vowed a vigorous fight. The FCC's action came despite well supported ongoing concurrent resolutions, opposing reallocation, in the US House (Resolution 317) and Senate (Resolution 127). All Amateurs must contact their Congressional Representative and Senators to protest this FCC action.

de W9JUV and N1ACH

Here it is! This issue marks one of the more significant milestones in the twenty-year history of HAM RADIO Magazine. As you leaf through this month's issue, you are going to see a blend of exciting new graphics carefully put together with a revised mix of the very best reading that you will find in Amateur Radio today.

This has not been an easy task. HAM RADIO has long enjoyed the unique reputation of being the most professional of any of the magazines in our field. Although we felt that it was time for some changes, we also recognized that it was vital to respect our past and build on what we have done so very well.

Over the past year, we've asked a lot of questions and listened very carefully to the answers. We have been talking to our readers, and to those who should be our readers, in an attempt to find out just how we could do an even better job in serving today's Amateur. Several important ideas continually dominated what we heard.

Don't let anything compromise the high technical standards that Jim Fisk set for HAM RADIO from the very beginning. We have always believed very strongly in this, and it was very reassuring to hear that so many of you overwhelmingly agree with us.

Print more construction articles and see to it that these projects are practical. Make sure they're constructed from available parts, suitable for the home builder to put together and get working properly in a reasonable amount of time.

Offer more short technical articles. Keep the quality there, but deliver more of it in smaller more easily digested pieces. Include these along with the longer, more in depth discussions readers expect from HAM RADIO.

It all adds up to a tall order, but I think we've managed to assemble what you've been asking for. From now on you'll be seeing at least two Weekenders each month. These short building projects are designed to stimulate your best workshop talents. We already have a backlog of really great projects waiting for you, and are continuing to scour the realm of Amateur Radio in our search for nifty stuff to direct toward your soldering iron.

We're going to be listening to what you like and don't like in the way of these projects. Look for the yellow page bound into this issue and you'll find details of our reader evaluation program. You can cast your vote each month and tell us which of our ideas really cut the mustard and which don't. To make it even more satisfying, you have a chance to win a handheld radio at the same time. Be sure to check this out and join in the fun.

We haven't forgotten our authors in all this excitement! The originator of each month's most popular project will also be awarded a handheld. Why don't you share the results of your latest brainstorm with our readers and see if you can't be our lucky writer one of these months? I'll bet you've already built the project. It's just a matter of putting your results on paper and sending it along to us.

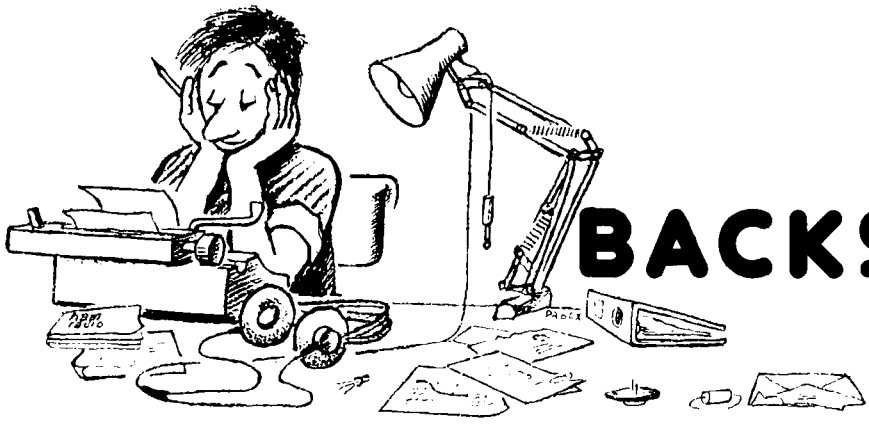
It's a very careful balancing act, but you'll see us putting a greater stress on the shorter tutorial pieces. However, as we said before, we will not be compromising the high standards you have learned to expect and enjoy in HAM RADIO Magazine.

You'll see a new look to our pages this month. It's been a long time since the original design was conceived. Our original layout has served us well and even now, over twenty years later, we are still the best looking Amateur magazine. But, much has changed in the technology and standards of the graphics arts field. It seemed that now was a perfect time to take advantage of all this and make HAM RADIO even more enticing. I'm sure you'll agree!

Finally, you will also find that two much requested old friends are back this month. The magazine is again in a mailing wrapper, and the reader service card has returned.

We've listened carefully, and we're going to keep tuning in for your comments and ideas. Use our evaluation card or drop us a note. Please let us know what you think of everything we're up to. It's being done especially for you. If it's not just right, then we want to make it so. We may already be the leader, but we want to do an even better job as your favorite Amateur Radio magazine.

Skip Tenney, W1NLB



BACKSCATTER

Field Day — Preparedness or Party Time?

Ask any Amateur — "What's the purpose of Field Day?" and you'll hear in response, "Test our ability to set up and operate under adverse conditions...Emergency preparedness...Demonstrate Amateur Radio's readiness to respond to disaster..." Surely noble intentions, but do they square with the realities of Field Day?

For most clubs, planning for a serious Field Day effort is a many month — often year-long — exercise. Picnic groves and company recreation areas are reserved, generators and cherry pickers rented, long lists of equipment, towers and antennas located and inventoried, operating crews organized and scheduled, and food and beverage needs tabulated. Then, at the appointed hour on the appointed Saturday in June, it all comes together when the bands come alive with big signals and each club's top ops grind out QSOs at a blistering pace.

For the next 24 hours we'll devour mountains of hotdogs and hamburgers washed down with oceans of coffee, pop and beer, while our "designated hitters" run up big contest scores in stations that are often as well laid out and equipped as a top-rated contest station. But what has all this got to do with "emergency preparedness," operation "under adverse conditions," or "readiness to respond to disaster?" Field Day as it's presently enjoyed is surely a great combination of multi-op contesting and early summer cookout, but adequate preparation for the next big earthquake or the day the dam breaks it ain't!

Isn't it time to decide what we really expect from Field Day? Should it be simply a multi-op contest operation in an outdoor setting, or should it become a serious effort to better prepare ourselves and our equipment for the day when smoothly functioning Amateur communications can save lives?

If the answer is better emergency preparedness, let's consider one way that might be accomplished. For example, instead of scheduling Field Day on a specific June weekend simply set it for some June weekend — to be announced by a "QST" from W1AW the Friday evening of that weekend. Consider how much more flexible your Field Day organization would have to be if it's going to have to set up and get on the air with less than 24 hours notice — how much more responsive, as in an actual unexpected emergency, you'd become!

In its present form Field Day is a great deal of fun and a fine opportunity to spend a weekend in the sun with some of your best friends. Maybe, without doing serious damage to that aspect of it, we could also turn it into a much more useful training experience. Any ideas?

Joe Schroeder, W9JUV

Sorry Joe. I don't buy it.

Field Day is one of the most enjoyable events we have in Amateur Radio. Every year thousands of Hams from across the country turn out. Prior planning of schedules allows many to rearrange vacations or business trips (or do the necessary chores) to accomodate their desire to operate. Plenty of Amateurs, who haven't missed a Field Day in years, might have to miss it due to other commitments if the change you propose was to be implimented.

This year, I participated in a Field Day effort with our local club. We hadn't done one before and, as we sat and planned our effort in the months preceeding the event, it became apparent that this group was *truly* excited. For new and old Ham alike, the spirit of Field Day was infectious. What didn't exist, however, was a cutthroat desire to win at all costs. Our desire was to set up a portable radio station in a suitable location and talk to as many others as possible.

I'm confident that from the lessons we learned, the club could put at least one station on the air in a few hours or less in the event of an emergency. The exper-

(continued on page 103)



COMMENTS

more information needed

Dear HR:

I picked up a copy of the June 1988 issue and saw your editorial. I think you may have missed part of the point.

The suggestion on encouraging old folks to become hams has considerable merit, but is that the only approach? I think the ham radio groups that have opened their hamfests to computerists are perhaps moving in a better direction, as the broadest field of potential hams is computer users of all ages. I suspect this has been a drawback of all the more "slick" ham magazines that they have minimized that aspect. Computer users are motivated toward electronics already.

Kids can get into computers from a keyboard — kids of all ages. (Perhaps that is why so many hams have gotten into them.) Can people get into ham radio by an as easily learned path? If they can, I haven't seen it in print. The kids overcome problems much more severe than Morse code with computers. The relation should be obvious, particularly with the advent of packet radio and ham radio teletype.

As I see it, there are two impediments. One is a simple but effective method of learning the code to the modest required speed. I and others have developed possible solutions to that. Laws are simple memory work. Neither of these need to be a roadblock.

As I see it, adequate simplification of basic electrical and electronic circuits along with suggesting simple circuits prospectives can build are needed. That was how many of us got started, and many of us have contributed to the advance of the field. But sound basics along with simple construction kits dependent on simple discrete elements are needed. Heathkits are no longer available for simple enough circuits for this. They have to be more mistake-resistant than most IC projects. The individual must be able to do the building without damaging either the parts themselves or the mounting circuit boards. (You can't easily find a kit meeting these requirements any more, at least ones suitable for starters. I have looked.)

In addition, it is not possible to put together even a simple audio amplifier that will work as planned based on data available. If one wants to make an audio amplifier using a bipolar transistor that will have a voltage gain of 50, one should use an audio oscillator source, a bipolar transistor with a load resistance of about 1200 ohms, with a direct voltage drop across the load resistor of about 1.25 volts. The series base resistance back to collector supply is adjusted to give the required voltage drop across the collector resistance. Have you ever seen that stated anywhere? Try it!

The point is that even this simple information is *not available* in any information source available for the potential ham. But any user of computers is a potential ham. He or she is eminently susceptible to trying something for use with a computer, and from there go to ham radio.

Present-day hams can't very well be experimenters based just on what is available in the ARRL handbook or most other sources because the important facts, such as why the above design works, are not available. (The transconductance of a bipolar transistor is (q/kT) times output current, and the voltage gain is that value times the load resistance, or in the above case about 48 to 50.)

We can correct this, and we need to correct this. But no one seems to care.

Keats A. Pullen, Jr., W3QOM,
Kingsville, Maryland 21087-1050

storing lead-acid batteries

Dear HR:

As I was reading the excellent article, "A Battery-backed Master Power System," by Eric Smitt, K9ES, I was disappointed by incorrect statements about lead-acid batteries. It cautioned against placing these batteries on concrete floors ("...the calcium in the floor will cause the battery to die.") and said they should be "Mounted on a wooden surface..." Such statements are unadulterated hogwash and I am disappointed that such a glaring error made it past the editors of Amateur Radio's finest technical publication.

Because a battery is contained within an insulating enclosure, there can be no electrical current between whatever it sits on and the internal cells. Similarly, because the battery case is chemically inert and impermeable, there can be no reaction between the environment and the internal chemistry of the battery.

What was stated has been an old "mechanic's tale" for years. As a college student, I worked as a "go-fer" in an automobile garage. One day, the mechanics and I had an argument about whether it was safe to set a lead-acid car battery upon a concrete floor or whether it should be set upon wood. I bet each of the mechanics that a brand new battery would not be affected by a concrete floor. The subject battery was to be compared to an identical new battery mounted upon a piece of wood. Both were to be left in place for about a month and receive no charging of any kind. Total battery voltage and cell specific gravity were the test parameters.

Need I state that I won the bet?

(continued on page 101)

A DIRECT DIGITAL SYNTHESIS VFO

Robert J. Zavrel, Jr., W7SX, c/o Digital RF Solutions, Inc., 3080 Olcott Street, Suite 200d, Santa Clara, California 95054

RF generated directly from digital information

The direct digital synthesizer (DDS) has arrived in Amateur Radio!* In the past several months DDS state of the art has progressed to the point where good radio performance is obtainable using DDS local oscillators. The DDS offers some attractive features over the analog or phase-locked loop (PLL) synthesizer. Like the PLL synthesizer, DDS is digitally controlled. Tuning is regulated by either memories or counters which, in turn, are controlled by rotary optical couplers. Unlike the PLL, DDS doesn't use a VCO, loop filter, phase detector, or digital divider and prescaler. Waveform information is generated using digital information only. The last step uses a digital-to-analog converter (DAC) to actually generate the rf signal.

review of local oscillator basics

The local oscillator is used to mix with the incoming received signal and produce the i-f signal. Because the i-f is usually fixed, a frequency agile LO is required if the received frequency is tuned. The LO signal should have excellent short and long term "drift" stability. It should also have adequate resolution or sufficiently small "step" sizes if digital control is used. Finally, it should be free from phase noise and spurious responses. The importance of phase noise specifications was demonstrated in an article by KI6WX.[1] Synthesizer science remains one of the most important areas in rf engineering, and improvements in these specifications are a continuing goal.

comparison of PLL and DDS techniques

Excellent drift stability has been achieved with PLL synthesizers; it is equally good with DDS. Frequency stability in both systems is determined by crystal reference stability.

Although drift characteristics are similar in DDS and PLL systems, others are not. For example, in PLL systems there is a tradeoff between the resolution and phase noise specifications. Generally, the smaller the step size the worse the phase noise. The step size represents the reference frequency for the PLL, perhaps 100 Hz. This signal must then be multiplied up to the LO frequency, usually 10's of MHz in an hf receiver. The phase noise contribution of the PLL is 20 log N, where N is the multiplier. Because N is usually very large, the phase noise is frequently difficult to minimize. This is not the case in DDS systems, where resolution is completely independent of phase noise. The VFO described here has a resolution of about 1.2-Hz. The addition of a second LSI CMOS phase accumulator (NCMO™) in this design could provide nanohertz resolution with no degradation in phase noise specifications, but 1.2 Hz resolution is more than adequate for most Amateur Radio applications.

Phase noise manifests itself as sidebands around the LO signal. In any modulation process AM, FM, or PM sidebands are generated in familiar ways. There are sidebands present in any oscillator signal; a spurious-free oscillator is only a theoretical ideal. A VCO in a PLL oscillator is controlled by a voltage that comes from a phase comparator by way of a loop filter. Both the comparator and filter are imperfect and consequently a noise voltage is superimposed on the dc control voltage. This noise signal, in turn, phase modulates the VCO. These sidebands are undesirable because they represent energy at frequencies offset from the main LO signal. The receiver will respond to signals offset from the desired receive frequency because of the mixing process. The reciprocal mixing process can limit the strong signal handling capabilities of the receiver and its dynamic range. Synthesizers with very low phase noise response are necessary to build high-performance

receivers. Recent model Amateur Radios using PLL synthesizers have begun to approach such specifications. But units employing an analog PTO oscillator can't be equaled for spectral purity. A properly designed LC analog oscillator is hard to beat for overcoming phase noise and spurious performance.

Spurious responses can also cause problems with LO signals. Unlike the "broadband" noise sideband response indicative of phase noise, spurs show themselves as secondary CW signals almost anywhere *in* the passband. They can be measured by a simple dB relationship with the LO carrier. Like the phase noise signal, a spurious LO signal can limit the dynamic range of the receiver. To maintain a 80-dB dynamic range, all spurs appearing in the LO signal must be at least 80 dB below the LO carrier.

DDS basics

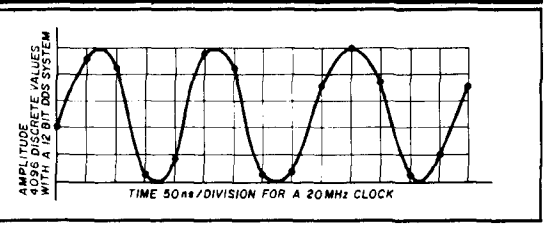
Figure 1 shows the key to understanding DDS systems. A 20-MHz clock has a period of 50nS. The Nyquist theorem states that a sine wave digital synthesizer needs at least two sample points per cycle. This fundamental law suggests that with a 50-nS sample rate the maximum possible output frequency is 10 MHz. This upper limit is called the "Nyquist frequency", one-half the clock frequency. The more samples per cycle the better the approximation will be. Consequently, better performance can be expected at lower operating frequencies in most DDS systems. The critical fact for DDS is that is doesn't matter *where* along the sine wave the samples are taken. If you can compute a continuous string of exact amplitude values (sinusoidal) and then convert these values to an analog signal, you can synthesize any quantized frequency approximation below the Nyquist frequency.

Amplitude computation is done with a specialized digital counter called a "phase accumulator". As **fig. 1** suggests, a discrete frequency can be defined as a specific change in phase-per-unit time. With a 20-MHz clock the unit of time is 50nS. Using the 50-nS sample rate, any discrete frequency can be *defined* by a discrete change in phase, $d\theta/dt = \Omega$.

The phase accumulator output is a digital bus that counts in a linear manner. Sine waves, on the other hand, vary sinusoidally. Therefore, you must convert a linear progression of numbers into a sinusoidal one. If the numbers are all digital, the easiest way to do this is with a read only memory (ROM). As the memory address is sequenced in a linear manner, the memory data bus outputs the appropriate amplitude value for that moment in time. The "oscillating" digital numbers are then applied to a DAC and the rf signal is the output. **Figure 2** shows a block diagram of a simple DDS system.

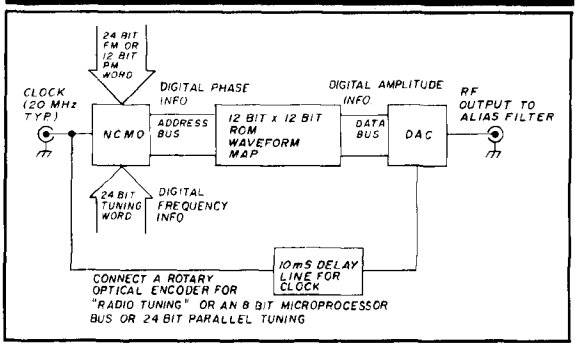
The present limitation of DDS is the spur level. This design renders all spurs below −75 dB in the desired 5

FIGURE 1



Sine wave generation using direct digital synthesis.

FIGURE 2



NCMO-based DOS synthesizer.

to 5.5-MHz VFO range. Typical spur response within the desired 500-kHz bandwidth is better than −80 dB.

The primary cause of spurious signal generation is nonlinearity in the DAC. The DAC state of the art has been evolving for the several decades, and a lucrative DDS market now gives DAC manufacturers an incentive to produce products with DDS applications in mind. In the next two years new fabrication techniques should produce DACs that realize −100 dB spur levels at 5 MHz. Faster DACs with higher resolution (more bits) will be required for better performance at higher frequencies.

If an ideal 12-bit DAC were used, the limit of spur suppression would be the quantizing error inherent to digital approximation. We haven't reached this level yet but I believe that we are very close, as figures and specs in this article suggest. Conventional wisdom suggests that a 6-dB improvement in spurious levels will be realized for the addition of one bit of resolution. (This makes intuitive sense because with each additional bit the voltage or current error will be halved, or −6 dB.) But convention doesn't hold to experimental evidence. At Digital RF Solutions we are seeing 8-dB/bit improvement in spurious response. If this rule holds, an ideal 12-bit DDS system would give a 96-dB spurious response. We haven't found adequate information quantifying the relationship between DAC linearity and the 8 dB/bit rate. The analysis will involve Fourier transformations and sampling theory.

*ICOM's 781 uses DDS. Ed.

the NCMO DDS system

The NCMO (conceived and designed by Earl McCune Jr., WA6SUH) is a highly integrated CMOS phase accumulator with numerous interface and modulation features. It uses a 24-bit phase accumulator counter controlled by a 24-bit tuning word. The 24-bit tuning resolution implies over 16 million equally spaced discrete frequencies in an NCMO system; 16 million "channels" suggests about 1.2-Hz steps with a 20-MHz clock. Half of the frequencies appear between the Nyquist and clock frequencies. These are simply "folded over" back below the Nyquist frequency, so there are actually only about 8 million possible discrete frequencies. Only the most significant 12 bits are used in this project. This affects only the sampling error and not the 24-bit frequency resolution. There is no advantage in using more ROM address bits than DAC resolution bits.

tuning

The NCMO can be tuned in three ways:

- a parallel mode connecting to 24 pins on the IC,
- a strobed mode for three eight-bit words, mainly for microprocessor interface,
- a serial mode which allows direct connection to a rotary optical coupler so it can "feel" like an analog tuner.

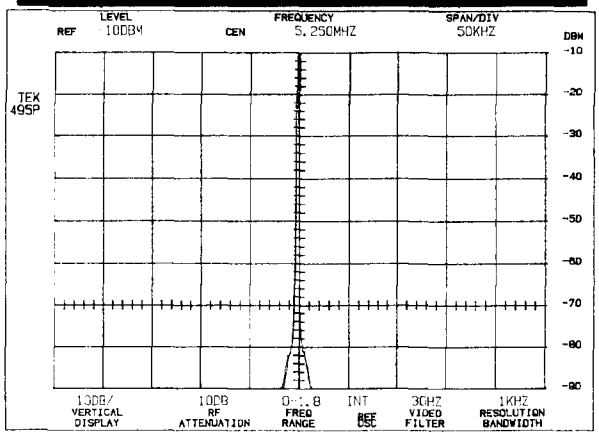
This VFO uses the serial mode. Interface to a tuning memory can be implemented, if you need or want such a feature. The tuning word can also be controlled by an external counter for a scanner, hopper, or search function.

modulation

These functions alone would make the NCMO a remarkable innovation. But WA6SUH also built FM and PM modulation into the NCMO. Another 24-bit port will accept a digitized modulating signal up to the Nyquist frequency! FM linearity is 24 bits; deviation is controlled absolutely and is constant from dc to the Nyquist frequency. Imagine a sweep oscillator with 24-bit sweep linearity from dc to 10 MHz. Because there is no loop time constant, QSY is effected in two clock cycles (or 100nS) with no settling time, and complete phase continuity. QSY from 4 Hz to 7.002052 MHz is possible without glitches in 100nS. The two most difficult functions in a signal generator — frequency agility and modulation — are performed digitally within the NCMO.

AM modulation can be effected by a digital multiplier inserted between the memory and DAC. This adjusts the instantaneous digital sinusoidal amplitude value just before data conversion. Single-quadrant multiplication yields full-carrier AM; four-quadrant multiplication yields double sideband suppressed carrier AM. Since AM, FM, and PM are accomplished simultaneously, any known form of modulation is possible within the constraints of Nyquist and 24-bit resolution. FSK is achieved by keying the appropriate number of FM bits for a desired deviation. A similar situation exists for PSK. Simultaneous AM and PM yield complex data communication constellations with direct digital control. Creating a 9600 baud, RTTY, DTMF, or any other digital encoding scheme is now a software function.

FIGURE 3



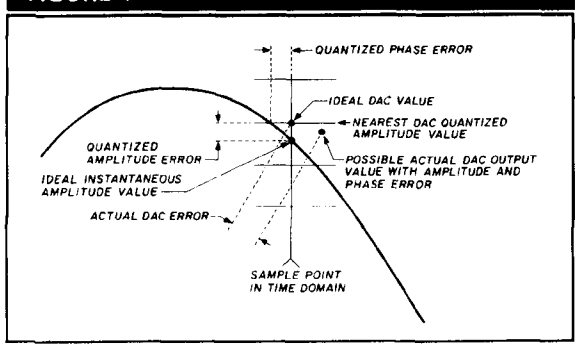
Spectrum of 5 to 5.5 MHz with the VFO set to 5.25 MHz. All spurious signals are below −80 dB.

the NCMO VFO

For on-the-air tests I have a Corsair II which uses a super low noise PTO VFO. The output level of the TRW1012 DAC is similar to the requirements of the Corsair (about +5 dBm). Switching back and forth between the Corsair VFO and NCMO VFO proved to be a good "qualitative" test. Results were excellent; only a few weak spurs were noted. The results were confirmed in our quantitative tests.

Figure 3 shows a spectrum of 5 to 5.5 MHz with the VFO set to 5.25 MHz. Note that all spurious signals are

FIGURE 4



Graph shows the ideal instantaneous amplitude value, error points due to quantized approximation or the ideal DAC value, and the DAC output error from the ideal DAC value. Phase noise and spurs result from both the quantized error and DAC errors.

below −80 dB. The close-in noise pedestal shown in this figure results from the phase noise of the Tektronix 495P spectrum analyzer, not the DDS synthesizer itself. Other measurements show the spurs down about −90 dB, with some special worst-case signals down about −75 dB. If absolute optimization is required, the worst-case spurs can be sent well outside the bandpass by adjusting the clock frequency 2 or 3 MHz. An interesting clock frequency is 16.777216 MHz. Here the step size will be exactly 1 Hz. This frequency also allows excellent spur shifting for a 5 to 5.5-MHz VFO.

spurs and phase noise

As stated earlier, the spurious signals originate in the DAC. There are two levels of DDS error — the DAC linearity contribution and the limits of quantization. **Figure 4** shows how these relate to an ideal sample point on a sine wave. Twelve-bit resolution implies 4096 possible amplitude values. Even an ideal DAC will provide an approximation of this value, giving rise to a minute amplitude and phase error. This is the quantized error. Because the DAC won't be ideal; it will miss the ideal quantized value, giving rise to additional error from DAC nonlinearity. The most important technique for minimizing spurs and noise is proper synchronization of the NCMO, memory, and DAC. The DAC and NCMO run off the same clock, but the signal from the NCMO "sees" a propagation delay through the ROM. A delay line must be included for the DAC clock assuring that the DAC's latched input "sees" a settled ROM address bus. Without this delay line, several bits can be in error and performance will be poor. Phase noise is also related to DAC linearity, but phase noise isn't a problem for the most demanding Amateur applications using the NCMO system. It is limited largely by the phase noise properties of the clock. An inexpensive digital clock is used in this project; much better phase noise performance is possible if you use a high-quality crystal and take care to build a high-quality clock oscillator.[1-6]

aliasing filters

Alias signals are produced in addition to the fundamental signal. The worst case alias signal falls between the Nyquist and clock frequencies. If we synthesize a frequency, F, this alias will appear at F(clock)-F. The closer you operate to the Nyquist frequency, the more difficult alias filtering becomes. This VFO uses a five-pole 7.5-MHz Chebychev low-pass filter of conventional design.[2] It is sufficient for filtering the 15-MHz alias at 5-MHz operation. More sophisticated filter designs can be used if needed.

specifications

The phase noise measurements in **table 1** were performed on an HP-3048A phase noise analyzer at E-Systems in Dallas, Texas. These phase noise specifications were taken with a low-noise HP clock. Using a typical $2.00 digital clock, the phase noise in dBc/Hz will be about −60 dB at 1 Hz, and settle in at about −135 at 1 kHz offset. Our most recent measurements using a low-noise reference indicate −110 dBc/Hz at 1 Hz, and an ultimate of about −145 at 1 kHz and greater spacing.

tests with the Corsair II

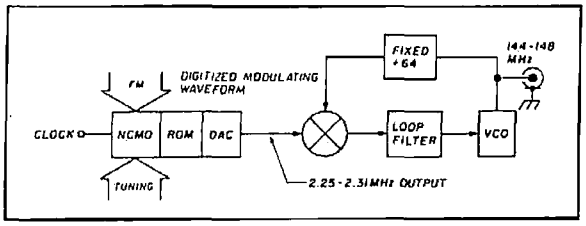
Two tests were performed with the Corsair II. There was no difference between the internal VFO and the NCMO for minimum sensitivity. There was also no difference in overload performance. A few additional weak spurs were observed using the NCMO that were not detected on the spectrum analyzer. This was expected because the receiver has a wider dynamic range than the analyzer. A 5 to 10 dB reduction in dynamic range can be anticipated at these discrete frequencies. However, only two or three of these spurs

TABLE 1

18X 2070 NCMO VFO specifications.

Specification		Units
Frequency coverage:	0-10.0	MHz
Tuning step size:	1.2	Hz
	or 19	Hz
	or 305	Hz
	or 4.9	kHz
	or 78	kHz
	or 1.25	MHz
	(selectable on front panel)	
Phase noise at 1 Hz offset	−95	dBc/Hz
10 Hz offset	−115	dBc/Hz
100 Hz offset	−128	dBc/Hz
1 kHz offset	−135	dBc/Hz
Spurious signal generation	−75 (worst case) dB	
	−90 (typical)	dB
Output level into 50 ohms	+3	dBm
Power supply	±5	volts
Circuit power consumption	1.5	watts

FIGURE 5



Use of a DDS system as a reference in a PLL multiplyer. A very low N value of 64 implies low phase noise output at 144 MHz. Both tuning and modulation are accomplished digitally at the NCMO.

were observed within the 5 to 5.5-MHz VFO range. Tuning is smooth, especially when using the 19-Hz step function. On-the-air tests produced excellent signal reports on transmit, indicating that the Corsair's specs weren't seriously degraded with this VFO.

other design configurations

VHF and UHF synthesis is possible using a DDS synthesizer as a reference in a phase-lock loop. Frequency agility and modulation in the 7 or 8-MHz range allow for low N values in the loop, minimizing phase noise and spurious levels. **Figure 5** shows a possible DDS/PLL VHF synthesizer.

If two waveform maps (sine and cosine) are used with two DACs, two signals in quadrature can be synthesized and will remain in excellent quadrature over the entire bandwidth (dc to Nyquist). Direct conversion SSB tranceivers can be built easily for 160, 80, and 40 meters using this design and references 7, 8, and 9.

Unfortunately, very little on DDS has appeared in print, particularly on practical designs and spurious minimization. Some of the better references can be found in the bibliography.

ordering information

You can purchase assembled DDS boards from Digital RF Solutions, Inc. *These boards are recommended for advanced experimenters. As a minimum, a low-frequency spectrum analyzer is required before attempting experimentation.* For more information contact Doug Hammed at 3080 Olcott St. Suite 200d, Santa Clara, CA 95054.

references

1. John Grebenkemper, KI6WX, "Phase Noise and its Effects on Amateur Communications-part 1," *QST*, March 1988, page 14.
2. Robert J. Matthys, *Crystal Oscillator Circuits*, Wiley-Interscience, 1983.
3. Ulrich L. Rohde, DJ2LR/KA2WEU, *Digital PLL Frequency Synthesizers*, Prentice-Hall, 1983.
4. Wes Hayward, W7ZOI, *Introduction to Radio Frequency Design*, Prentice-Hall, 1982.
5. Sabin, Schoenike, et al., *Single-Sideband Systems and Circuits*, McGraw-Hill, 1987.
6. *The 1988 ARRL Handbook for the Radio Amateur*, available for $20.95 plus $3.50 shipping and handling from the *ham radio* Bookstore, Greenville, New Hampshire 03048.
7. Robert J. Zavrel, Jr., W7SX, "ICs Simplify Design of Single-Sideband Receivers," *EDN*, April 1986.
8. Robert J. Zavrel, Jr., W7SX, "New Low Power Single-Sideband Circuits," Signetics Application Note no. AN1981.
9. Gary A. Breed, K9AY, "A New Breed of Receiver," *QST*, January 1988, page 16.

bibliography

1. Neil Albaugh, N7BBN, "New ADCs for Signal Processing," *RF Design*, November 1987.
2. Earl W. McCune, Jr., WA6SUH, "Direct Digital Synthesis and the Number Controlled, Modulate Oscillator," Proceedings RF Technology Expo, February 11-13, 1987.
3. Fred Williams, "A Digital Frequency Synthesizer," *QST*, April 1984, page 24.
4. Robert J. Zavel, W7SX, "Digital Modulation Using the NCMO," *RF Design*, March 1988, page 27.

Article A · ham radio

"NEW" SUPER LINEAR ANTENNA SYSTEM

MODEL	FREQUENCY	GAIN	POWER	LENGTH	USE	PRICE
CA-2x4z	146 MHZ 446 MHZ	8.2dB 11.5dB	200 W	15'4"	Base	$192.85
CA-1243E	446 MHZ 1.2GHZ	8.5dB 10.1dB	100 W	4'8"	Base	$ 85.95
CA-901	146/446/1.26GHZ	3/6/8.4dB	150 W	3'5"	Base	$ 91.55
CFC-771	900-930MHZ	7.14dB	50 W	4'5"	Base	$ 97.40
CA-1221S	1260/1300	15.5dB	100 W	7'8"	Base	$151.90
CA-2422S	2400/2450	15.3dB	100 W	4'8"	Base	$173.55

NEW! SWR Power Minimeters

CM	200 —	144 - 150 MHZ	$ 62.50
CM	300 —	200 - 230 MHZ	$ 62.50
CM	400 —	420 - 460 MHZ	$ 62.50
CM	900 —	900 - 930 MHZ	$ 93.50
CM	1200 —	1200 - 1300 MHZ	$ 93.50

DUAL & TRI BAND MOBILE ANTENNA'S DUPLEXERS - TRI PLEXERS
Dealer inquiries welcomes.

NCG

(714) 630-4541
1275 N. Grove St., Anaheim, CA 92806

Specifications and prices subject to change without notice or obligation.

152

5-1000 MHZ PREAMPLIFIERS

	NF	G	P(1dB)	$
WLA21m	3dB	13dB	8dBm	57
WLA22m	4	11	12	61
WLA23m	4	23	12	87
WLA24m	3	20	18	109

430/50MHZ CONVERTER

RCX431 .15μV 20dB 99



WILAM TECHNOLOGY, Div. of
WI-COMM ELECTRONICS INC.
P.O. Box 5174, MASSENA, N.Y. 13662
(315) 769-8334

153



THE WEEKENDER

AN EASY-TO-BUILD NiCd PULSE CHARGER

R. L. Measures, AG6K, 6455 La Cumbre Road, Somis, California 93066

The solid metal plate nickel-cadmium (NiCd) battery was invented around 1900, and it had one serious drawback. High internal resistance caused the cell voltage to fall to very low levels with heavy loads, restricting its use to low-current applications. This limitation persisted for about 35 years until the sintered-plate NiCd battery was invented in Germany.

Sintering is a processs that heats a tightly packed mass of microscopic-sized metal spheres to just below the melting point and then compresses them until surface fusing takes place at the points where they touch. The result is a semi-solid block of welded metal particles with a tremendous surface area — a *metal sponge*. Since chemical activity can take place only where the liquid electrolyte touches the surface of the metal, the large surface area gives the sintered plate a chemical activity area hundreds of times larger than a solid plate of the same dimensions. This reduces the internal resistance of the sintered-plate NiCd cell to an incredibly low value. I have an H-Type wet cell NiCd battery rated at 26 volts/5.7Ah (ampere hours). It is a small 15-pound battery, and yet the per cell voltage drops <0.06 volts with a 40A/1000 watt load! This means that each cell has a resistance of <0.002 ohms. The rated maximum current load for this battery is 150A. It is *very* dangerous to short out this battery.

The sealed type of NiCd used in Amateur Radio equipment is also a sintered-plate type. It too is capable of producing dangerous fireworks if it is shorted out, but on a smaller scale than the H-Type NiCd (designed for gas turbine and piston engine starting service).

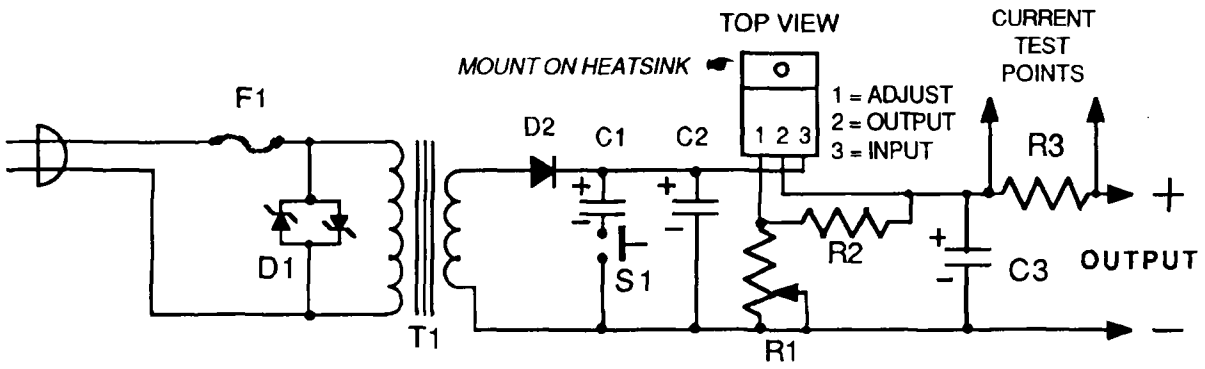
The process of charging a sintered-plate NiCd battery is complicated by the fact that a charge must be delivered not only to the surface particles on the sintered plate, but also to the particles buried inside the plate. A slight overcharge must be applied to the surface particles in order to get to the buried particles and achieve a full charge. To do this you must apply a substantial minimum current during the charging process. This minimum charging current is usually one-tenth of the Ah capacity (C) of the cell. This is written as "0.1C".

If the charging current of 0.1C is maintained after a wet cell NiCd battery is fully charged, the surplus charging energy that the battery can't store converts the water in the cell's liquid electrolyte to hydrogen and oxygen gas. This causes no damage to the cell as long as distilled water is added periodically to maintain the proper electrolyte level. It's not convenient to add water in a sealed NiCd cell; an internal process of turning the hydrogen and oxygen gas back into water is designed into the cell. When hydrogen and oxygen unite to form water they release energy in the form of heat, causing cell heatup. If the cell is continually cooled enough to maintain cell temperature below $\approx 35°C$, the sealed cell won't be damaged by overcharging. If the cell temperature is allowed to rise above $\approx 35°C$ during charging, the cell won't last long.

The problem with most NiCd battery packs is that no provision is made to cool the batteries during the charging process. If you leave your handheld transceiver plugged into a 0.1C constant-current wall charger for the recommended 14 to 16 hours and the pack is only 50 percent discharged at the beginning of the charge time, the batteries will overheat during the last ≈ 8 hours of the charge cycle and their life expectancy will be shortened considerably. Should you inadvertently leave an initially 100 percent discharged battery pack on the charger for more than 16 hours, the cells will overheat and the batteries will die young.

You can eliminate overcharging by using a constant voltage to charge the batteries. With constant-voltage charging, you use approximately 1.43 volts per cell to charge the batteries. The initial cell voltage is low compared to the constant-charge voltage, so the initial charge current is high. As the cells become charged, their voltage rises and the charge current decreases below the critical 0.1C level. This is both good and bad. It is good that the cells will not be overheated by being force-fed current after they have become charged; it is bad because not enough current will be supplied near the end of the charging process to fully charge the deep parts of the plate. The result is that

FIGURE 1



D1: small (9mm size) metal-oxide varistor rated at line voltage used.
D2: 3A, >100 PIV silicon rectifier.
C1: >220 µF 35 volts.
C2, C3: >1µF 35 volts tantalum mounted close to the IC.
F1: 0.5A for 100-125 volts line voltage. 0.25A for 200-250 volts line voltage. 3AG.
R1: 1k, multiturn trimpot. If more than nine NiCds are to be charged use 2k.
R2: 100 ohm 1/4 watt.
R3: Charge current sampling resistor. 1 ohm, 2 watt for charging AA batteries. 0.1 ohm, 2 watt for charging C or D batteries. Monitor the voltage across the resistor with a DMM or oscilloscope. For the 0.1 ohm resistor: 1 millivolt = 10 milliamperes.
T1: >1A secondary. If nothing larger than an AA cell is to be charged, a 0.5A transformer is adequate. Secondary voltage depends on how many cells are to be charged. Esec = 1.1 x (number of cells) + 3 volts, RMS. The no-load secondary voltage must be ≤ 24 volts RMS.

Schematic of NiCd pulse charger.

Note: D1 is an MOV.

only about 80 percent of the rated C of the battery can be realized by constant-voltage charging.

A method of charging is needed with a current that doesn't drop below the critical 0.1C level or cause the unsafe cell heating found with constant-current charging. The solution is voltage-limited pulse charging. The needed current of ≥0.1C is pulsed at a greatly reduced duty cycle, so the average heat dissipated by the cell is reduced to a safe level. The pulse discharger's disadvantage is that while it produces a higher C than constant-voltage charging, it won't allow 100-percent utilization of a battery's C. This is a small tradeoff for greatly extended battery life.

There have been several articles on pulse chargers for NiCds over the last few years, but none of the ones I saw were easy to build. I designed my pulse charger with this in mind. **Figure 1** shows the schematic.

circuit description

The pulse source for this charger is the half-wave rectified line frequency. Pulse duration is about 8.33mS with 60-Hz line frequency; the time between pulses is 16.67mS. Because the battery will be charged only when the charger voltage exceeds the battery voltage, it is the crest of the half-wave pulse that charges the battery. The duration of this charging pulse is ≈2mS to 3mS. The resting time between charge pulses is ≈13mS. The maximum voltage of the pulse is controlled by an LM-317T adjustable three terminal regulator IC. The output current is monitored by measuring the voltage drop across a known resistance (R3). The varistor (D1) in the charger takes care of the voltage spike that appears across the transformer windings and the half-wave rectifier (D2) when the charger is unplugged from the power source.

The recommended transformer current rating of ≥1A may seem high but is necessary for two reasons. First, half-wave rectification is especially hard on a transformer since a dc current flows in the secondary of the transformer. Second, the available peak current at the beginning of a charge cycle needs to be high enough to assure that any reversed cells will be automatically repolarized. If you need higher current output, the 5A LM-338 can be used in place of the LM-317T along with a heavier transformer, fuse, one-tenth of the resistance of R3, and a 6A rectifier (D2).

adjustment

Follow the steps below to make adjustments to the charger.

With no battery connected to the charger, depress S1 and set R1 for an output voltage of ≈1.43 volts per NiCd cell to be charged. Release S1.

Connect a DMM across the current test points. The initial average charge current will be about 0.3C which will decline as the battery is charged; the charge current plateaus after the cells are fully charged. R1 should then be reset for a charge current of ≈0.02C.

You can see the peak charging current on an oscilliscope by connecting the scope across the current test points. The peak charging current should be ≈0.1C when the average charging current is 0.02C. The transformer secondary voltage may be too high if it is less that 0.1C, or the current-monitoring resistor (R3) may

need to be reduced by a factor of 10 times. This changes the calibration factor.

There won't be any damage to the battery if it is left connected to this charger for several days. However, you shouldn't charge the battery if the ambient temperature is above 35°C or 95°F.

myths about NiCds

Some people believe that it's best to let a NiCd pack run completely down to 0 volts before recharging. This is an acceptable practice with solid-plate NiCds, but it is the quickest way I know to short out a sintered-plate NiCd battery. According to one NiCd manufacturer, General Electric, a NiCd battery should never be discharged below 1.1 volts per cell. Allowing the cell voltage to go to 0 may also cause one or more of the cells in a battery pack to reverse polarize in the last few minutes of discharge. The normal constant-current charge rate of 0.1C isn't usually enough current to reverse the wrong polarity of the cell. This means that one cell won't recharge until it is reversed by a much larger current. A voltage-regulated pulse charger can usually supply enough initial charging current to reverse a reversed cell.

Another myth about NiCd batteries is that they have a "memory" which causes them to lose C. I have seen many NiCds that have lost part of their C; this was due to loss of electrolyte caused by overcharging and overheating. New NiCds can gain C after a few charge/discharge cycles and this appears to be a normal occurrence with newly manufactured cells. I have never seen the "memory effect" discussed in some NiCd literature.

Many feel that NiCds can be expected to last only a couple of years. This is probably true if they are carelessly charged with a constant-current charger. The 26 volt/5.7Ah battery I mentioned earlier was made in 1962. The two paralleled halves of this battery (13 volts) will still start an automobile engine.

A final myth is that NiCds should be stored fully discharged and shorted out. This is almost certain to cause an eventual, but fatal, short circuit between the plates of a sintered-plate NiCd. The proper way to store a NiCd is to charge the battery, place it in a sealed plastic container (so that it can't be inadvertently shorted), and put it in a freezer compartment. You'll need to repeat this process every 3 years.

disadvantages of NiCd cells

Besides being dangerous if shorted out, NiCds also have some other disadvantages. One of these is the problem of self-discharge. At room temperature, a sealed NiCd cell loses about 1 percent of its stored energy daily with no load on the battery. Self-discharge is highly dependent on the ambient temperature. Reducing the ambient temperature 10°C cuts the self-discharge rate in half. An ordinary freezer with a temperature of −15°C causes only about 1/20th of the self-discharge rate that you could expect on a warm summer day.

Another pesky problem with NiCds is their flat discharge curve. They maintain a cell voltage of ≥1.15 volts right up to the end. Unlike carbon-zinc or alkaline-manganese cells, the end comes without warning. The only way to keep track of the remaining charge in a NiCd is with a high-resolution 3-1/2 digit DVM.

summary

Nickel-cadmium cells have their limitations. They wouldn't be good to use in smoke detectors, watches, or any place where low self-discharge is essential. But they work well for portable handheld transceivers. The only thing they require is a charger that can't inadvertently heat them during charging.

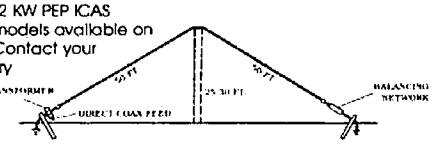
Article B **ham radio**

CONTINUOUS COVERAGE ANTENNAS
FOR COMMERCIAL & AMATEUR SERVICE

Model AC 1.8-30 — 1.8 to 30 MHz

- SWR Max 2:1, 1.4:1 overage from 1.8 to 30 MHz
- Can be installed in approximately 80 ft. space
- Ideal for commercial services for multi frequency operation without the need for antenna tuners or additional antennas
- Handles 1 KW, 2 KW PEP ICAS
- Higher power models available on special order. Contact your dealer or factory

$175.00 SHIPPING & HANDLING ADD $4.00

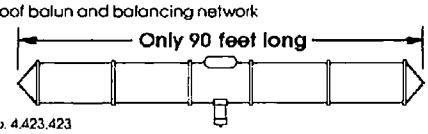


U.S. Patent No. 4,511,898

Model AC 3.5-30 — 3.5 to 30 MHz

- SWR less than 2:1 from 3.5 to 30 MHz
- Complete assembled. Balun terminated with standard SO-239 connector
- Power capability 1 KW - 2 KW PEP ICAS. Higher power model is available on special order.
- Designed for 50 ohm feedline
- Weather proof balun and balancing network

$184.50 SHIPPING & HANDLING ADD $4.00



U.S. Patent No. 4,423,423

ALL OUR PRODUCTS MADE IN USA
B·W BARKER & WILLIAMSON
Quality Communication Products Since 1932
At your Distributors. Write or Call.
10 Canal Street, Bristol, PA 19007
(215) 788-5581

MEASURING TRANSMISSION LINE PARAMETERS

A. E. Popodi, OE2APM/AA3K, Moosstrasse 7, A-5020, Salzburg, Austria

Three methods of determining velocity factor

There are several applications that require fairly accurate knowledge of the velocity factor of a transmission line. The ratings listed in data sheets and tables are only approximations, and the velocity factor varies not only between different suppliers but between different sections of cable on a reel.

Say, for example, you want to find the length of a coax cable that is half a wavelength long. Because this length (or an integral multiple of it) reproduces its load impedance (for instance, the impedance of an antenna) at its input, you can make remote antenna measurements via this cable.

input impedance measurement

The simplest, although not the most accurate, method is to short circuit the cable and place a 51-ohm resistor in series with its input and a signal generator (see **fig. 1**). Monitor the cable input voltage with an rf voltmeter and adjust the frequency for minimum input signal.[1] Consider a section of RG-58 C/U coax that is 19.93 feet long. To predict the lowest frequency at which the input impedance is 0, calculate the frequency that corresponds to a full wavelength for a cable whose velocity factor (v) is 0.66 (used as a starting point).

FIGURE 1

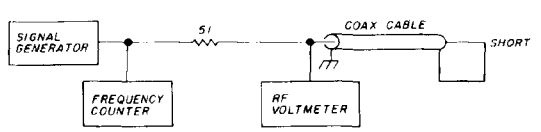


fig. 1. Signal generator is adjusted until rf voltmeter dips to lowest value.

$$f_o = \frac{984 \cdot 0.66}{\ell} \quad (1)$$

where f_o is the frequency in MHz and ℓ the cable length in feet. Based on a velocity factor of 0.66, frequency f_o would equal 32.587 MHz. So, for half the frequency of f = 16.293 MHz, this cable is half a wavelength long and the input voltage is 0 because the cable output is shorted. Now make an actual frequency measurement and incorporate its value in the following formula:

$$v = \frac{f \cdot \ell \cdot 2}{984} \quad (2)$$

If the measured frequency is determined to be f = 16.131 MHz, the velocity factor becomes:

$$v = \frac{16.131 \cdot 19.93 \cdot 2}{984} = 0.653$$

three-coil method

Figure 2 shows a three-coil method presented by George Downs, W1CT.[2] It uses a grid dip meter in conjunction with three different coils connected to the input of the cable with a shorted output. The test procedure is as follows:

- Prepare three coils by winding a No. 20 bare wire with a 0.25-inch coil diameter. Space turns evenly with short pigtails on each coil. Make coils with three, two, and one turns, respectively.
- Solder the three-turn coil to the cable input. Determine the resonant frequency with a grid dip meter and monitor the frequency with a frequency counter. Use minimum coupling.
- Repeat this test with the other two coils.
- Plot the results (turns versus frequency) on linear graph paper as shown in **fig. 3**. Find the frequency at which you can calculate the velocity factor by extrapolating the curve (asymptote) to zero turns. You may be able to obtain a nearly straight line by spacing

FIGURE 2

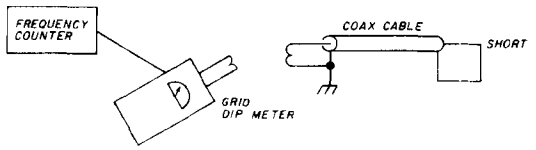


fig. 2. Three different coils are used to generate data.

FIGURE 3

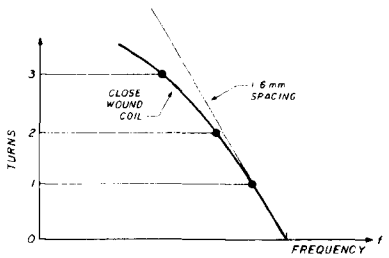


fig. 3. Asymptote intersects frequency axis at "zero turn" point. This frequency when substituted into *eqn. 2* determines velocity factor.

FIGURE 4

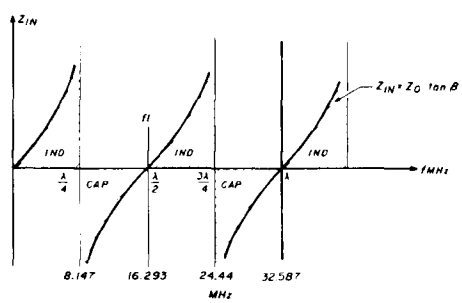


fig. 4. Inductive and capacitive substitution method of determining velocity factor depends on alternating reactance sign of input transmission line impedance.

the turns properly. **Figure 4** explains how this method works. It shows the input impedance (in this case a pure reactance) of a 19.93-foot shorted and *lossless* cable versus frequency, and for a velocity factor of 0.66. Note that the input impedance is a pure capacitance between 8.147 and 16.293 MHz and the cable can be resonated by an external inductance. At frequencies between 16.293 and 24.44 MHz the cable is inductive and can be resonated by an external capacitor. In both cases, you have a parallel-tuned resonant circuit. The smaller the external inductance, the closer the frequency is to the half-wavelength frequency of 16.293 MHz.

This explains why it is impossible to determine cable length accurately with a grid dip meter and coupling coil. You resonate the external inductance with the cable capacitance, but do not measure the correct frequency f_1 in this way.

The method's main disadvantage lies in the difficultly of making a one-turn coil because its pigtails affect the value of its inductance. In practice, the three points in **fig. 3** don't always line up very well.

three-capacitor method

By using external capacitors, you can operate the cable as the inductive element of a parallel-tuned circuit. The obvious advantage is that you can measure capacitances precisely. The voltage peak at resonance is easy to observe and accuracy is better than with the previous methods. Since you have a parallel-tuned circuit, you must feed the signal from a high impedance source. A 4.7 k resistor is sufficient (see **fig. 5**).

- Determine the resonant frequencies for each of three different capacitors.
- Calculate the three capacitive reactances:

$$\frac{1}{\omega C} \qquad (3)$$

where C is the total external capacitance and $\omega = 2\pi f$, with f the resonant frequency for each respective capacitor.

- Plot the curve:

$$\frac{1}{\omega C}$$

versus f and extrapolate the curve to find the intersection point on the frequency axis.

- Insert this value in **eqn. 2**.

Add the input capacitance of the rf voltmeter to the external capacitor value and measure the physical length of the cable as accurately as possible. If you

FIGURE 5

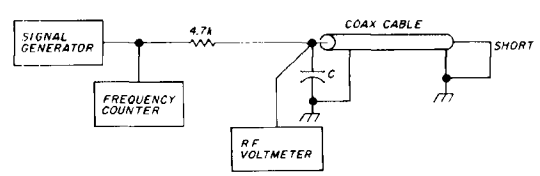


fig. 5. Third and most accurate method of determining velocity factor utilizes capacitors that resonate with the cables inducting reactance.

Look at our MOBILE MARK
"ON WINDOW" Line

VHF
(140-175)
- No Hole
- Easy to Mount
- Rugged
- Superior Performance
- Radiator Snaps On and Off
- Competitively Priced



UHF
(420-520)
- 3 db gain
- No Hole
- Easy to Mount
- Rugged
- Superior Performance
- Radiator Snaps On and Off
- Competitively Priced

MODEL OW 3-150
140-174 MHz
MODEL OW 3-220
210-250 MHz
- 3 db gain
- No Hole
- Easy to Mount
- Rugged
- Superior Performance
- Swivel Vertical Adjustment
- Radiator Removal Without Loss of Vertical Adjustment
- Competitively Priced





MOBILE MARK, INC.
COMMUNICATIONS ANTENNAS
3900-B River Road
Schiller Park, IL 60176
312-671-6690

brings imagination and innovation to antennas ..... and has been since 1948 !!

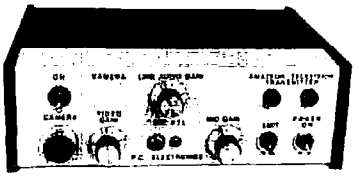
124

AMATEUR TELEVISION

NOVICES: NOW YOU CAN TRANSMIT VIDEO WITH OUR NEW TX23-1

Did you know that you as well as all classes of licensed amateurs can easily transmit live action color and sound video just like broadcast TV with our TX23-1 transmitter. Use any home TV camera and/or VCR, computer, etc. by plugging the composite video and audio into the front 10 pin or rear phono jacks. Call or write now for our complete ATV catalog including downconverters, transceivers, linear amps, and antennas for the 70, 33, & 23cm bands.

Only $299



TX23-1 one watt ATV transmitter crystaled for 1289.25 MHz runs on 12-14 Vdc @ .5A. PTL T/R switching. 7x7x2.5". Transmitters sold only to licensed amateurs for legal purposes verified in the latest Callbook or with copy of license sent with order.

(818) 447-4565 m-f 8am-5:30pm pst.

P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006

Tom (W6ORG)
Maryann (WB6YSS)

125

don't have access to an rf voltmeter; build a single-stage amplifier (A simple wide-band, RC coupled one) followed by a rectifier, using voltage doubling. Then amplify the resulting dc voltage with a 741 operational amplifier that drives a meter. Feed the amplifier by way of an emitter follower to reduce the probe capacitance that forms part of the total capacitance. If you can select the cable length, choose one longer than 16.4 feet in order to keep the resonant frequency in the range of 10 to 20 MHz and reduce the effect of parasitic inductances.

The capacitors must be connected with the shortest possible leads between center conductor and shield. (I recommend using a small pc board as a groundplane and ground reference.) If the capacitor leads are too long the apparent capacitance is increased, due to the series inductance, and the measured resonance frequency will be lower — falsely indicating a smaller value of velocity factor.

Consider a piece of RG-58 C/U coax, 21.01 feet long. The three values of capacitance chosen are 235 pF, 773 pF, and 1658 pF (which includes 3 pF for the probe capacitance). **Table 1** shows the measured frequencies and the corresponding calculated values of capacitive reactance.

TABLE 1

Measured frequencies and calculated values of capacitive reactance.

C	pF	235	773	1658
f	MHz	18.377	16.58	16.0
$\frac{1}{\omega C}$	Ω	36.85	12.42	6.0

Before plotting the curve:

$$\frac{1}{\omega C}$$

versus frequency, calculate the input impedance of this cable for a velocity factor of 0.66 and a characteristic cable impedance of 50 ohms. The input impedance of a shorted cable can be calculated from:

$Z_{IN} = Z_0 \tan\beta$

where Z_0 is the characteristic cable impedance and β its electrical length in degrees. At the half-wavelength point (f = 16.293 MHz), β is 180 degrees and the input impedance is 0. For a frequency of 16.4 MHz, for example, the corresponding β value is:

$$\beta = 180 \cdot \frac{16.4}{16.293} = 181.18 \text{ deg} \qquad (4)$$

and Z_{IN} = 1.03 ohms. You can draw the whole curve Z_{IN} versus frequency for v = 0.66 and Z_0 = 50 ohms, as shown in **fig. 6** (curve A). A frequency of f = 15.46

MHz is found by extrapolation of curve B. Using **eqn. 2**, you will obtain:

$$v = \frac{15.46 \cdot 21.01 \cdot 2}{984} = 0.66$$

The measured points on curve B line up well. Drawing the curve for v = 0.66 (curve A) facilitates the plotting of the measured curve.

measuring the characteristic impedance of a cable

A good method for measuring Z_0 is to use two different termination resistors R_A and R_B (different from Z_0) and then measure the corresponding input impedances $Z_1 = R_1 + jX_1$ and $Z_2 = R_2 + jX_2$ with an impedance bridge. The termination resistors can also be 0 and infinite (short circuit and open circuit). In general, you should select termination resistors that provide input impedances well within the measuring range of the bridge. Calculate the characteristic cable impedance from:

$$Z_o = \sqrt{\frac{(Z_1 - R_A)\, R_B\, Z_2 - (Z_2 - R_B)\, R_A\, Z_1}{Z_1 - Z_2 - R_A + R_B}} \quad (5)$$

Since Z_1 and Z_2 are complex quantities, the calculations are quite cumbersome.

The advantage of the three-capacitor method is that the characteristic impedance Z_0 can be obtained easily from the plot

$$\frac{1}{\omega C}$$

versus frequency. By referring to **fig. 6**, you'll see that curve A was calculated for Z_0 = 50 ohms and v = 0.66. Curve B of the example has the same intersection point at the X-axis of 15.46 MHz (because v = 0.66), but it has a higher slope than curve A. Because the mathematical representation of curve A is:
$Z_{IN} = Z_0 \tan \beta$
the slope of the curve is governed by the value of Z_0. By taking the

$$\frac{1}{\omega C}$$

values of f = 18.2 MHz, for example, you'll find 31.2 ohms and 34 ohms. This makes the Z_0 value for this cable:

$$Z_o = 50 \cdot \frac{34}{31.2} \cong 54.5 \text{ ohms} \quad (6)$$

If the velocity factor were smaller than 0.66, curve B would lie to the left of curve A. If v is smaller than 0.66 and Z_0 is larger than 50 ohms, you must shift the curve to the right, until it has the same intersection point as curve A, to determine the slope difference.

FIGURE 6

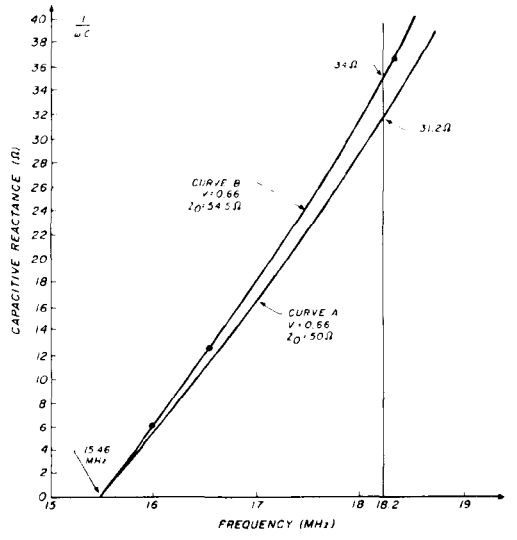


fig. 6. Data from curves used to determine a transmission line's characteristic impedance.

summary

I have presented three methods of measuring the velocity constant of a transmission line. In all three, the cable output is shorted. The first method uses a small series resistor of 51 ohms between the cable input and signal generator. The frequency at which the cable input voltage is at a minimum can be used to calculate v.

The second method employs three different inductors at the cable input and uses the cable as the capacitive element of a parallel-tuned circuit.

The third, and most accurate, method uses three or more different capacitors of known value at the cable input, with the cable acting as the inductive part of a parallel-tuned circuit. The circuit is fed by a high value resistor from a signal generator. From the plot

$$\frac{1}{\omega C}$$

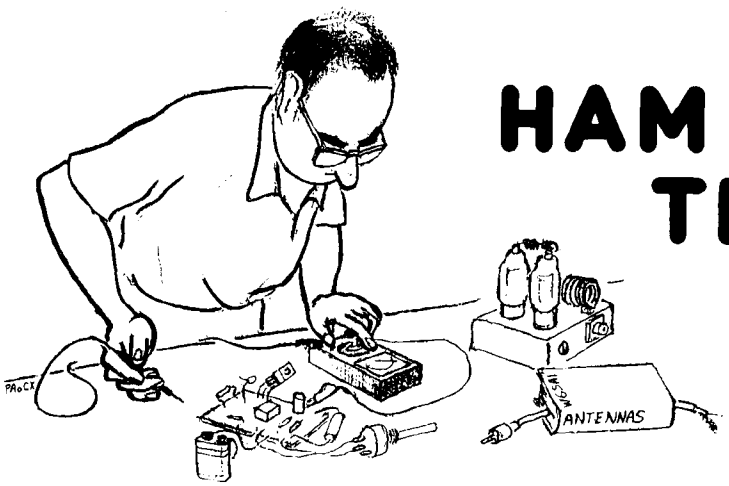
versus frequency, the velocity factor (v) can be calculated.

This same plot can be used to calculate the characteristic impedance Z_0 of a cable more easily than with other existing methods, and without the need for an impedance bridge and time-consuming calculations.

references

1. Joe Carr, K4IPV, "Practically Speaking: Coax Velocity Factor," *ham radio*, November 1986, page 79.
2. George Downs, W1CT, "Measuring Transmission Line Velocity Factor," *QST*, June 1979, page 27.

Article C **ham radio**



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

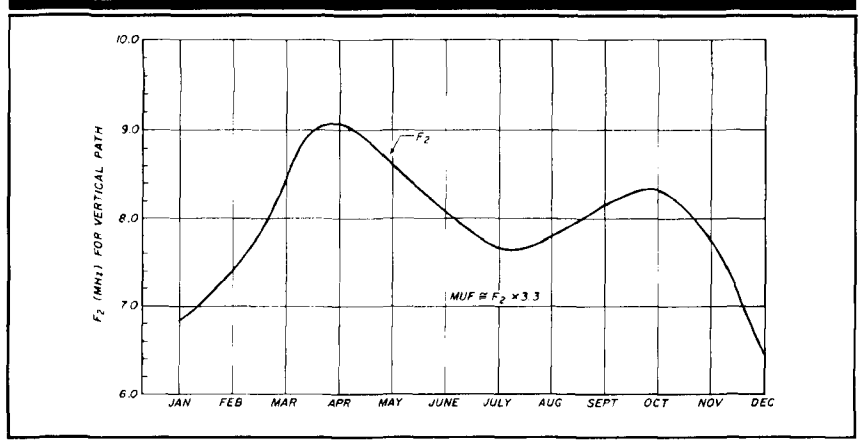
on our way up!

"**Been down for so long** it feels like up to me!" That's the story of the sunspot cycle and DX. At last things are on the way up. The sun is getting spottier and the higher frequency Amateur bands are coming to life.

Of course it didn't seem that way during the summer months. DX tends to fizzle out in warm weather and there's a lot of short skip in its place. But DX will pick up again in the fall months, as it has for many years.

My good friend Steve, KH6SB, has maintained a running record of various aspects of the solar cycle over a period of 34 years. Steve is stationed at the NOAA Ionospheric Research Station at Maui, Hawaii. The graph in **fig. 1** is my copy of his record (taken in Maui) of the ionospheric measurements of the maximum reflection frequency of the F2 layer, as measured by the radio sounder. This critical frequency is that of a pulsed radio wave, projected vertically to the ionosphere, whose reflected signal is monitored at the sounder site. At Maui, the MUF (maximum usable frequency) is about 3.3 times the maximum measured reflection frequency. The graph shows what most DXers know from experience — the best DX months are in the spring (March and April) and the fall (September and October). Winter and summer months are poorer because the average MUF is lower. The 10, 12, and 15-meter bands are particularly sensitive to this annual cycle.

FIGURE 1



Recorded maximum frequency of vertical incident sounder (Maui) averaged over 34 years.

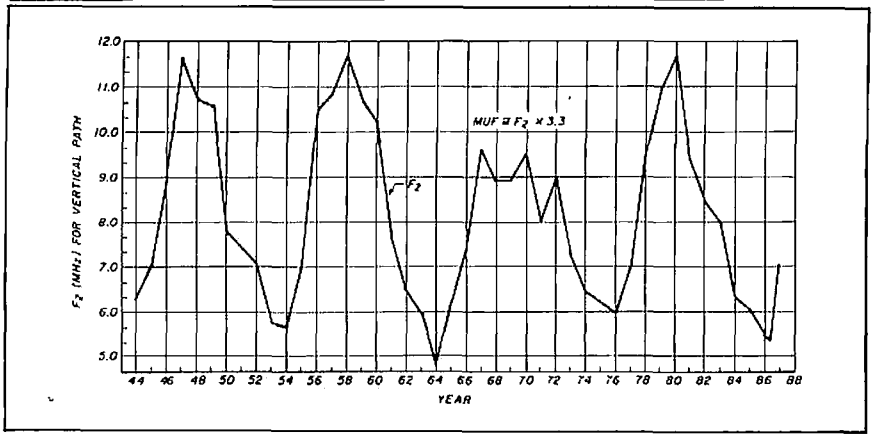
You might infer from the graph that spring is better than fall for DX on the higher bands. This may be true for Hawaii, but not necessarily for the rest of the world. The chart gives a quick overview of the ionosphere and its effect on DX conditions, as logged over three decades of observation.

what about September?

And what about the month of September? **Figure 2** shows the record of F2 vertical sounding for September since 1944 and covers over four sunspot cycles. The factor of 3.3 shows that during sunspot minima (1986, for example) the median vertical sounding frequency averaged about 5.5 MHz, indicating that the MUF ran around 18 MHz. During the minimum year of 1976, the September MUF averaged around 19.8 MHz. But during the very low period of September 1964, the MUF averaged only 15.8 MHz. This was good news for the 20-meter DXer who operated near the edge of the MUF, but bad news for the operator on 15 and 10 meters. (The actual median values shown are for a 24-hour period, and the MUF near noon is probably higher than the values discussed.)

On the other hand, during the great sunspot cycle year of 1957, the September median value of MUF may have run as high as 39.6 MHz; for the October period of that year, the MUF

FIGURE 2

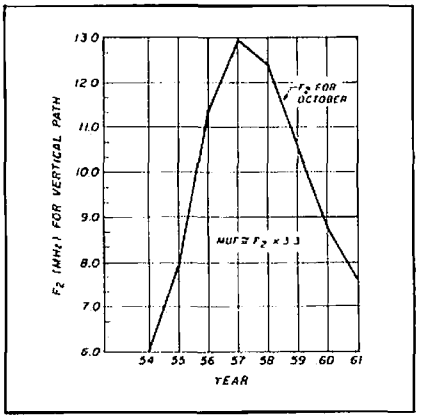


F_2 vertical sounding record (Maui) over 4 sunspot cycles (month of September).

ran as high as 43.5 MHz! (See **fig. 3**.) Looking back at old copies of *QST* magazine, I found reports of fabulous 50-MHz DX in late 1957. The East Coast was working Hawaii, the West Coast was working South Africa and Europe, and the MUF was reaching occasional peaks of 52 MHz!

What are the probabilities of DXers being able to repeat the fabulous conditions of the fall of 1957? Some specialists think the chances are good for a high sunspot cycle peak in a year or two. If this comes to pass, the 50-MHz band will explode with strong DX signals from all over the world. I'm keeping my fingers crossed on that one!

FIGURE 3



During October 1957 the median MUF peaked near 43.5 MHz.

the darker side

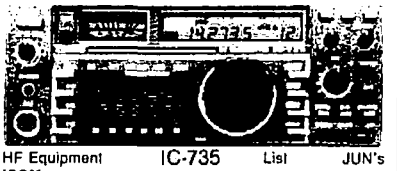
A high sunspot count is welcomed by the DXer who "pushes" the MUF — increases his operating frequency as the MUF rises. For the operator who prefers the lower frequencies, a high sunspot count is bad news. As the operating frequency falls behind the MUF, the absorption of signals increases and conditions deteriorate. Thus the "DX-ability" of 160 through 20 meters will decline as the solar cycle progresses. I remember that at the peak of the 1968 cycle 20 meters would be dead for days, while 10 meters was full of enticing DX signals. Forty and 80 meters were not considered serious DX bands. Old DX columns in *QST* confirm these facts. A perusal of these columns gives a good indication, in retrospect, of how conditions really are at various periods during the sunspot cycle. So look ahead to good DX conditions on 15 and 10 (and possibly 6) meters and poorer conditions on 160, 80, 40 (and possibly 20) meters.

MININEC revisited

The classic MININEC antenna analysis program developed by the Naval Oceanic Systems Center is well known to many Amateurs. It is used to model antennas for any operating frequency within the range of the antenna design. It can evaluate published designs, modify an existing antenna, or create a new antenna design at the

800-882-1343

ICOM



HF Equipment IC-735	List	JUN's
ICOM		
IC-781 New Deluxe HF Rig	$5995	Call $
IC-761 Loaded with Extras	2699	Call $
IC-735 Gen. Cvg Xcvr	1099	Call $
IC-751A Gen. Cvg Xcvr	1699	Call $
Receivers		
IC-R7000 25-1300* MHz Rcvr	1199	Call $
IC-R71A 100 kHz-30 MHz Rcvr	999	Call $
VHF		
IC-228A/H	509/539	Call $
IC-28A/H FM Mobile 25w/45w	469/499	Call $
IC-02AT FM HT	409.95	Call $
IC-2GAT 2m 7w HT	429.95	Call $
IC-900 Six Band Mobile	639	Call $
UHF		
IC-48A FM Mobile 25w	509	Call $
IC-04AT FM HT	449	Call $
IC-4GAT 440MHz HT	429.95	Call $
220 MHz		
IC-38A 25w FM Xcvr	489	Call $
IC-32AT 2m/70cm HT	629.95	Call $

KENWOOD

KENWOOD HF Equipment		
TS-940S/AT Gen. Cvg Xcvr	2449.95	Call $
TS-440S/AT Gen. Cvg Xcvr	1379.95	Call $
TS-140S Compact Gen. Cvg Xcvr	929.95	Call $
VHF		
TS-711A All Mode Base 25w	1029.95	Call $
TR-751A All Mode Mobile 25w	649.95	Call $
TM-221A 2m 45w	439.95	Call $
TM-2550A FM Mobile 45w	499.95	Call $
TM-2570A FM Mobile 70w	599.95	Call $
TH-215A 2m HT Has It All	379.95	Call $
TH-25AT 5w Pocket HT NEW	349.95	Call $
TM-721A 2m/70cm FM Mobile	649.95	Call $
UHF		
TM-421A Compact FM 35w	449.95	Call $
TH-45AT 5w Pocket HT NEW	369.95	Call $
220 MHz		
TM-3530A FM 220 MHz 25w	499.95	Call $
TM-321A Compact 25w Mobile	449.95	Call $
TH-315A Full Featured 2.5w HT	399.95	Call $

YAESU

YAESU HF Equipment		
FT-767 GX Gen. Cvg Xcvr	1929.95	Call $
FT-757 GX II Gen. Cvg Xcvr	1129.95	Call $
FT-747 GX New Economical Performer	889.95	Call $
FL-7000 15m-160m AMP	1995.00	Call $
VHF		
FT-212RH NEW 2m 45w	459.95	Call $
FT-712RH 70cm 35W	499.95	Call $
FT-290R All Mode Portable	599.95	Call $
FT-23 R/TT Mini HT	344.95	Call $
FT-209RH FM Handheld 5w	389.95	Call $
VHF/UHF Full Duplex		
FT-736R, New All Mode 2m/70cm	1749.95	Call $
Dual Bander		
FT-727R 2m/70cm HT	439.95	Call $
FT-109RH New HT	399.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

1989 CALLBOOKS



THE QSL BOOK!

Continuing a 68 year tradition, we bring you three new Callbooks for 1989, bigger and better than ever!

The North American Callbook lists the calls, names, and address information for 495,000 licensed radio amateurs in all countries of North America, from Canada to Panama including Greenland, Bermuda, and the Caribbean islands plus Hawaii and the U.S. possessions.

The International Callbook lists 500,000 licensed radio amateurs in countries outside North America. Its coverage includes South America, Europe, Africa, Asia, and the Pacific area (exclusive of Hawaii and the U.S. possessions).

The 1989 Callbook Supplement is a new idea in Callbook updates, listing the activity in both the North American and International Callbooks. Published June 1, 1989, this combined Supplement will include thousands of new licenses, address changes, and call sign changes for the preceding 6 months.

Every active amateur needs the Callbook! The 1989 Callbooks will be published December 1, 1988. Order early to avoid disappointment (last year's Callbooks sold out). See your dealer now or order directly from the publisher.

☐ North American Callbook	
incl. shipping within USA	$29.00
incl. shipping to foreign countries	35.00
☐ International Callbook	
incl. shipping within USA	$32.00
incl. shipping to foreign countries	38.00
☐ Callbook Supplement, published June 1st	
incl. shipping within USA	$13.00
incl. shipping to foreign countries	14.00
SPECIAL OFFER	
☐ Both N.A. & International Callbooks	
incl. shipping within USA	$58.00
incl. shipping to foreign countries	68.00

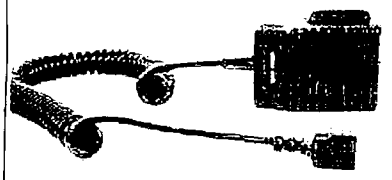
* * * * * * * * * * * *

Illinois residents please add 6½% tax.
All payments must be in U.S. funds.

RADIO AMATEUR **callbook** INC.
Dept. F
925 Sherwood Dr., Box 247
Lake Bluff, IL 60044, USA

Tel: (312) 234-6600 VISA

NOVEX Speaker Mics



High quality audio • Privacy earphone jack
Rotatable lapel clip • Hi-Lo volume switch

ICOM IMC-32H
Kenwood IMC-32K
Yaesu IMC-32Y

SUPER VALUE
only $19.95
+ Shipping & Handling

NOVEX Handsets



PTT handset • backlit DTMF • Private listening
Wired for most current ICOM, Kenwood, Yaesu & others (on special request)

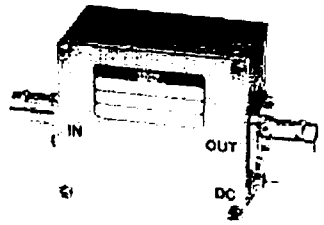
ICOM HCS70H, Kenwood HCS70K, Yaesu HCS70Y
Available for many other radios at slightly higher prices

Introductory price $79.95
+ shipping & handling

✓ 128

EEB Orders: 800-368-3270 (Local & tech: (703) 938-3350)
Electronic Equipment Bank
5710 Mill St. NE, Vienna, VA 22180
(just minutes from Washington, D.C.)

THE LAST AMPLIFIER YOU WILL EVER NEED!
7MHz - 1300 MHz



ONE AMPLIFIER MANY APPLICATIONS:

- Receiving-Ultra high dynamic range-Low noise.
- Transmitting-Driver or final...1 watt linear output.

Gain	15 dB ± 1dB
IP3	+ 44dBm
IP2	+ 73dBm
N.F	HF-UHF 4.5dB (typ)
1dB Comp	+ 30dBm
Connectors	BNC

PRICE $199 ✓ 129
Add $4.00 ship USA
CA Res. add 6%

ADVANCED MILLIWAVE LABORATORIES, INC.
620 HAMPSHIRE RD., A3
WESTLAKE VILLAGE, CALIFORNIA 91361
TEL. (805) 495-7858

user's command. When used with a beam antenna, it will provide forward gain, front-to-back ratio, beam width, side lobe levels, input impedance, azimuth and elevation patterns, and more.

MININEC is designed for the IBM PC and compatible computers. While suitable for Amateur Radio applications, some modifications can make it even easier for hams to use. Brian Beezley, K6STI, has generated an MN antenna analysis program suited to the Amateur.* MN requires an IBM PC or compatible machine with about 250K of free memory; the plotting program requires an additional 150K. You'll need a Hercules Graphics Card to view the plots, but the MN analysis program can use any display.

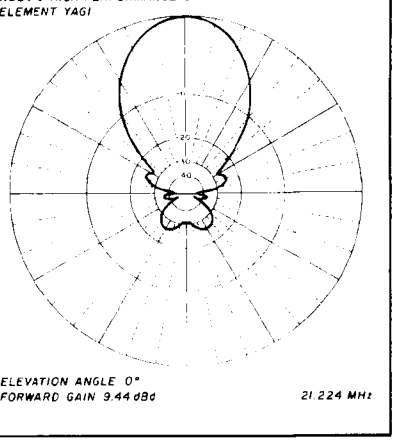
The MN program contains over 50 predesigned antenna files in its library and gives an easy starting point for antenna modeling. The plotting program provides azimuthal and elevation plots like those shown in **figs. 4** and **5**. The latter shows the first plot I've ever seen of a terminated Beverage antenna, popular on 160 meters. Note the excellent front-to-back ratio of the 2-wavelength antenna! Note also that at an elevation of 10 feet, this Beverage wire shows the main lobe to be at an elevation angle of about 26 degrees. The gain of the Beverage is about 6 dB less than a dipole. But this is of little consequence because the comparative loss in signal strenth can be recovered easily in the receiver preamplifier.

160-meter beacon signals

A group of mysterious beacon signals are heard during the June-September period on the 160-meter band. They are most noticeable in the Northwest and Alaska. Dan, KL7Y, reports hearing them as early as June and as late as September, after which time they vanish. It is assumed the beacons are used during the fishing season by Japanese or Russian commercial fishing fleets in the Bering Sea or northern Pacific. In periods of good

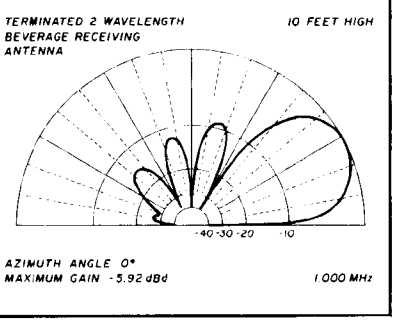
*For information on the MN program send an SASE to K6STI, Bryan Beezley, 507-1/2 Taylor Street, Vista, California 92084.

FIGURE 4



MN program plot of 6-element Yagi (21 MHz) pattern.

FIGURE 5



MN plot of 2-wavelength Beverage antenna (1.8 MHz) elevation pattern.

propagation, Dan has heard as many as 26 different beacons in a day. A smaller number are heard on the West Coast. They are not heard in the Midwest, and apparently are not heard in the southern Pacific area either. KL7Y reported that he heard a QSO in progress between WØZV and Australian stations directly on top of a beacon and neither operator appeared to hear it. **Table 1** gives a list of some of the beacons and their approximate frequency.

The frequency range of 1800-1810 kHz is reserved for radiolocation in Region 1 of the ITU (International Telecommunications Union); this includes an area of the Bering Sea near the coast of Siberia. Radiolocation is also permitted in Region 2 (the Americas). It seems that the legality of the beacons is a fuzzy matter that may be open to question. Reports on these signals from other areas of the world would be welcome.

TABLE 1

160-meter beacon signals*

Frequency (kHz)	Beacon Identification (CW)
1800	DS45
1803	OU42
1805	OS13, Z12—
1817	4XI
1820	ZI8—, HI53—
1822.5	LO5
1823	BD6
1825	GGI, 6VOD, BA1—
1827	NI9—
1828	YKT5—
1833	ZA4—
1835	AI6—
1841	BD1—
1848	550A—
1863	GL1, XC4
1865	LN3—
1870	5X4
1871	N6AT (not a ham call!)
1873	KJ38
1962	IK43
1964	BD3—, K8—, DH2, DU2
1977	TA7W
1993	OR36

(— indicates a long dash following the ID)
*Compiled by KL7Y.

Orr's familiar quotation

In my last few columns I have given a well-known quotation from a popular book, just to see if you're on the ball, or if you're only "couch potatoes" alternating between the tube and the operating desk. Here's another quotation from a popular book. Give me the title of the book and the author:

"I keep picturing all those little kids playing some game in this big field of rye and all. Thousands of little kids, and nobody's around — nobody big, I mean — except me."

What book? What author? If you know, send me the answer on your QSL card. I'll list all who are correct. My QTH is Box 7508, Menlo Park, California 94025.

Article D **ham radio**

RF POWER TRANSISTORS

We stock a full line of Motorola & Toshiba parts for amateur, marine, and business radio servicing

SEE YOU AT THE ANAHEIM, PORTLAND & BOXBORO HAMFESTS

Partial Listing of Popular Transistors in Stock
Matched Pairs and Quads Available

P N	Net Ea	P N	Net Ea
BFR96	$ 2.75	SD1407	$25.00
J310	1.00	SRF2072	12.75
MRF134	16.00	SRF3662	24.00
MRF136	21.00	SRF3800	17.50
MRF137	24.00	U310	1.75
MRF138	35.00	2N1522	11.95
MRF150	87.50	2N3553	2.25
MRF174	80.00	2N3771	3.50
MRF208	11.50	2N3866	1.25
MRF212	16.00	2N4048	11.95
MRF221	11.00	2N4427	1.25
MRF224	13.50	2N5109	1.75
MRF226	14.50	2N5179	1.00
MRF227	3.00	2N5589	7.25
MRF237	2.00	2N5590	10.00
MRF238	12.50	2N5591	13.50
MRF240, A	15.00	2N5641	9.50
MRF245	27.50	2N2642	13.75
MRF247	26.00	2N2643	15.00
MRF260	7.00	2N5945	10.00
MRF262	8.75	2N5946	12.00
MRF264	10.50	2N6080	6.25
MRF317	56.00	2N6081	8.00
MRF421	24.00	2N6082	9.50
MRF422	36.00	2N6083	9.75
MRF428	50.00	2N6084	11.50
MRF433	11.00	2SC730	1.25
MRF499, A	12.50	2SC1307	3.00
MRF450	13.50	2SC1946, A	15.00
MRF453	15.00	2SC1947	9.75
MRF454	14.00	2SC1969	3.00
MRF455	11.75	2SC2075	3.00
MRF458	20.00	2SC2097	28.00
MRF460	44.00	2SC2166C	3.50
MRF475	3.00	2SC2290	16.75
MRF476	2.75	2SC2312	4.95
MRF477	11.75	2SC2509	9.00
MRF479	10.00	2SC2630	28.00
MRF485 MP KEN	18.00	2SC2640	15.00
MRF492	16.00	2SC2641	16.00
MRF497	14.25	2SC2879	22.00
MRF515	2.50	3N204	2.00
MRF555	3.00	3N211	2.00
MRF607	2.50	40582	7.50
MRF630	4.25	*OUTPUT MODULES*	
MRF641	18.00	SAU4 450 MHz	55.00
MRF644	21.00	SAU17A 903 MHz	50.00
MRF646	25.00	SAV6 150 MHz	42.50
MRF648	31.00	SAV7 146 MHz	42.50
MRF660	10.75	SAV12	23.50
MRF637	2.25	SAV15 222 MHz	48.00
MRF843	22.50	M57712,M57733	use SAV7
MRF846	37.75	M57737, SC1019	use SAU4
MRF873	24.50	SC1027	61.00
MRF901	1.25	MHW710-2 3	89.50
MRF911	2.00	MHW820-2	
MRF966	2.75	*TUBES*	
NE25537	2.75	12BY7A	5.75
NE41137	2.50	572B/T160L	83.00
PT9847	21.00	6146B	14.00
RF120	22.00	4CX250B	95.00
SD1278-1	13.75	3-500Z	125.00

Hi-Gain, Matched, and Selected Parts Available
MATCHED TUBE FINALS IN STOCK FOR HAM EQUIPMENT
WE SERVICE ATLAS, ASTRO & SWAN—CALL FOR INFO

RF Power transistors in stock for Atlas, KLM, Collins, Yaesu, Kenwood, Cubic, Mirage, Motorola, Heathkit, Regency, Johnson, Icom, Drake, TWC, Wilson, GE, etc. Cross-reference on CD, PT, SD, SRF, JO, and 2SC P Ns.

Quantity Pricing Available COD / VISA / MC

Ship/Hand. 1 lb. U.S. or Foreign Sm Pkt Air 8 oz. $5.00

Orders received by 1 PM PST shipped UPS same day. Next day UPS delivery available

PARTS ORDERS ONLY — NO TECHNICAL
(800) 854-1927

ORDER LINE and/or TECH HELP
(619) 744-0728
FAX 619-744-1943

RF PARTS
1320 Grand Avenue
San Marcos, CA 92069

GREAT CIRCLE COMPUTATIONS USING LOTUS 1-2-3®

Thomas M. Hart, AD1B, 54 Hermaine Avenue, Dedham, Massachusetts 02026

In the last few years, there have been a number of interesting articles in various Amateur publications about computing great circle angles and distances. For the most part, the articles have featured BASIC programs driven by a set of formulas available in standard reference works. They all do a good job and are designed for a variety of computers, from the Sinclair ZX-81 through time-sharing terminals. With very little effort, most of the programs can be adapted to virtually any computer able to run one of the many dialects of BASIC.

I think a far better solution to the problem of computing great circle calculations is available in the form of an electronic spreadsheet like Lotus Development Corporation's 1-2-3. This article presents the information necessary to set up a simple spreadsheet that, in theory at least, can record more than 8,000 target locations and compute the angle and distance to each in a neatly formatted report. In practice, because of memory limitations, something on the order of 2,500 target locations can be stored. The resulting data can be sorted and presented in any order (distance, angle, alphabetical). A new starting point can be entered and all the information for successive locations can be rapidly recomputed. A useful way to use the spreadsheet might be to enter the name, QTH, latitude, and longitude of all the members of a 20-meter net. A customized print could then be prepared for each of the participants, listing the angles and distances to all the other members. On a smaller scale, you could enter the latitudes and longitudes of the members of a 2-meter net on a spreadsheet and generate the antenna bearings from each member to the others.

Electronic spreadsheets are productivity tools often found in educational or business applications. Spreadsheet programs allow the use of a very complete set of mathematical functions, including trigonometric formulas like tangent, sine, and cosine. The most popular spreadsheet program is 1-2-3, although many others like Microsoft's Multiplan®, Software Group's Enable®, and Lotus' Symphony® have similar features. You should be able to adjust the formulas in this article to work with any of the other major spreadsheets. With the proliferation of IBM (and clone) equipment during the last few years, using one of the major spreadsheets is just as practical as programming in BASIC.

The sample worksheet in **fig. 1** shows a few international targets by angle and distance from my own QTH; if I were to change the starting latitude and longitude to another station, the new computations would be completed in seconds. This is one of the

FIGURE 1

GREAT CIRCLE WORKSHEET
AD1B

ENTER SOURCE LONGITUDE AND LATITUDE IN DECIMAL DEGREES:

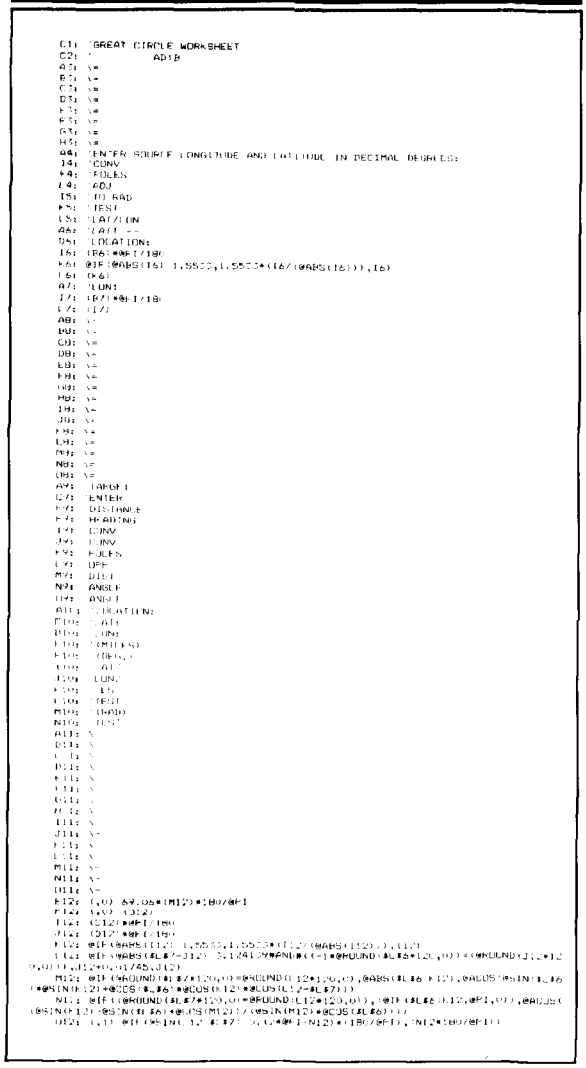
LATI ---: 42.2 LOCATION: Dedham, Ma.
LONI ---: 71.2

TARGET LOCATION:	ENTER LAT:	LON:	DISTANCE (MILES)	HEADING (DEG.)
BAGHDAD	33.4	-44.4	5,809	49
BANGKOK	13.5	-100.6	8,547	10
BOGATA	4.0	75.0	2,650	186
BOMBAY	19.0	-72.5	7,612	37
BUENOS AIRES	-35.0	58.0	5,399	169
CAIRO	30.0	-31.2	5,427	60
CAPE TOWN	-34.0	-18.0	7,765	117
CHICAGO	41.9	87.6	838	274
DUBLIN	53.4	6.2	3,001	52
ISTANBUL	41.2	-29.0	4,827	52
MOSCOW	56.0	-37.5	4,482	36
PARIS	48.9	-2.2	3,440	56
PERTH	-32.0	-116.0	11,621	328
RIO de JANEIRO	-22.9	43.3	4,839	153
ROME	41.9	-12.4	4,098	59
SAN FRANCISCO	37.8	122.4	2,683	281
STOCKHOLM	59.2	18.1	3,759	39
TEHRAN	35.8	-51.5	5,944	43
TOKYO	35.7	-139.8	6,707	335
WARSAW	52.2	-21.0	4,082	46

Sample worksheet for great circle computations.

great advantages of a spreadsheet over a BASIC program. You can create a database, in this case the list of cities around the world, and manipulate the information for a variety of purposes. The computer screen shows the final report in the form it will take when sent to the printer.

FIGURE 2



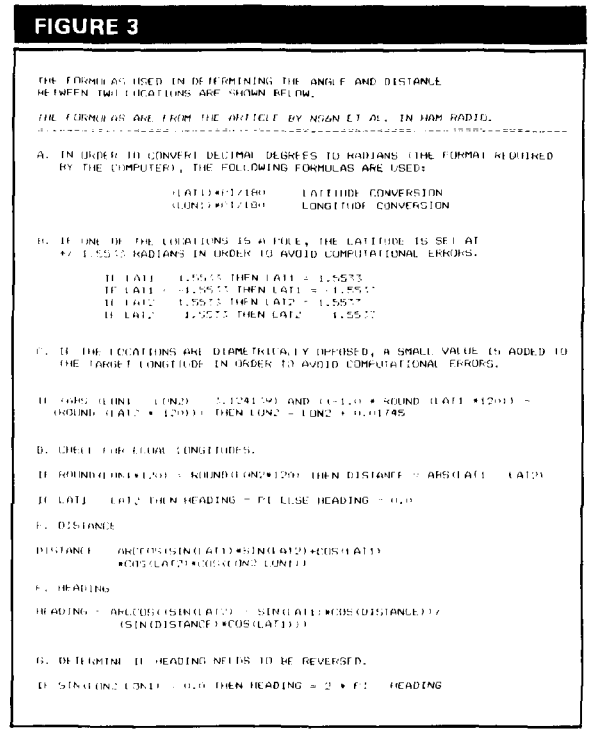
```
C1: 'GREAT CIRCLE WORKSHEET
C2: '          AD1B
A5: \=
B5: \=
C5: \=
D5: \=
E5: \=
F5: \=
G5: \=
H5: \=
44: 'ENTER SOURCE LONGITUDE AND LATITUDE IN DECIMAL DEGREES
14: 'CONV
+A: 'POLES
L4: 'ADJ
I5: '0.RAD
+5: 'TEST
L5: 'LAT/LON
A6: 'LAT1 --
B6: 'LOCATION1
I6: @RADIANS(B6)
+A: @IF(@ABS(I6) 1.5533,1.5533*(I6/@ABS(I6)),I6)
I6: 0.61
A7: 'LON1
I7: @ATAN(1)*8/180
L7: I7/
A8: \-
B8: \-
C8: \=
D8: \-
E8: \=
F8: \=
G8: \=
H8: \=
I8: \-
J8: \=
K8: \=
L8: \=
M8: \=
N8: \=
O8: \=
A9: 'TARGET
C9: 'ENTER
F9: 'DISTANCE
F9: 'HEADING
I9: 'CONV
J9: 'CONV
K9: 'POLES
L9: 'DEG
M9: 'DIST
N9: 'ANSWER
O9: 'ANGLE
A10: 'LOCATION
B10: 'LAT
B10: 'LON
I10: '(MILES)
I10: '(DEG.)
I10: 'AT
I10: 'LON
K10: 'IS
L10: 'DEG
M10: '(RAD)
N10: 'DIST
A11: \
B11: \
C11: \
D11: \
E11: \
F11: \
G11: \
H11: \
I11: \-
J11: \-
K11: \
L11: \
M11: \-
N11: \-
O11: \-
B12: (0.0) A9.06*(M12)*180/@PI
F12: 0.0) (D12)
I12: (C12)*@PI/180
J12: (D12)*@PI/180
K12: @IF(@ABS(I12) 1.5533,1.5533*(I12/@ABS(I12)),I12)
L12: @IF(@ABS(L8/8-312) 5.1243)*@NUM((-1)*@ROUND(L8/8*120,0))+(@ROUND(J12*12
0/@PI,0)/120+@ROUND(J12*180/@PI,0)/120)
M12: @IF(@ROUND(L8/8/120,0)=@ROUND(I12*120,0),@ABS(L8/8-I2),@ACOS(@SIN(L8/8
*@SIN(I12)+@COS(L8/8)*@COS(I12)*@COS(L12-L8/8)))
N12: @IF(@ROUND(L8/8*120,0)=@ROUND(I12*120,0),(@IF(L8/8-I12,@PI,0)),@ACOS(
(@SIN(I12)-@SIN(L8/8)*@COS(M12))/(@SIN(M12)*@COS(L8/8)))
O12: (-1)*@IF(@SIN(J12-K12)<0,0,@PI-N12)+(180/@PI),N12*180/@PI)
```

Listing of entries to create a 1-2-3 spreadsheet.

In addition to the sample output sheet, I have included a listing of the entries in **fig. 2** to create a 1-2-3 worksheet and a listing of the formulas in **fig. 3** used in creating a great circle spreadsheet. Once this file is *complete*, simply copy the formulas from line 6 down for as many lines as you need. The formulas are designed to work in a combination of absolute and relative references so that they may be copied as many times as required.

To prepare your own great circle worksheet, refer to **fig. 2** listing; it contains two sections. The first column is comprised of a reference to the cell where text and formulas are to be entered. For example, "C1:" means that the first cell in column "C" receives the information that follows on the same line of the listing. Text entries are indicated by an apostrophe as the first character in the string. The apostrophe itself is not typed into the worksheet, but is generated by the computer whenever it detects a text entry. A formula has no apostrophe and, once again, is entered as shown in the listing.

FIGURE 3



```
THE FORMULAS USED IN DETERMINING THE ANGLE AND DISTANCE
BETWEEN TWO LOCATIONS ARE SHOWN BELOW.

THE FORMULAS ARE FROM THE ARTICLE BY NS6N ET AL. IN HAM RADIO.

A. IN ORDER TO CONVERT DECIMAL DEGREES TO RADIANS (THE FORMAT REQUIRED
   BY THE COMPUTER), THE FOLLOWING FORMULAS ARE USED:

                (LAT1)*@PI/180      LATITUDE CONVERSION
                (LON1)*@PI/180      LONGITUDE CONVERSION

B. IF ONE OF THE LOCATIONS IS A POLE, THE LATITUDE IS SET AT
   +/- 1.5533 RADIANS IN ORDER TO AVOID COMPUTATIONAL ERRORS.

        IF LAT1   1.5533 THEN LAT1 = 1.5533
        IF LAT1 = -1.5533 THEN LAT1 = -1.5533
        IF LAT2   1.5533 THEN LAT2 = 1.5533
        IF LAT2 = -1.5533 THEN LAT2 = -1.5533

C. IF THE LOCATIONS ARE DIAMETRICALLY OPPOSED, A SMALL VALUE IS ADDED TO
   THE TARGET LONGITUDE IN ORDER TO AVOID COMPUTATIONAL ERRORS.

IF @ABS (LON1 - LON2)   3.1241592) AND ((-1.0 * @ROUND (LAT1 *120)) =
  @ROUND (LAT2 * 120)) THEN LON2 = LON2 + 0.01745

D. CHECK FOR EQUAL LONGITUDES.

IF @ROUND(LON1*120) = @ROUND(LON2*120) THEN DISTANCE = @ABS(LAT1 - LAT2)

IF LAT1   LAT2 THEN HEADING = PI ELSE HEADING = 0.0

E. DISTANCE

DISTANCE    @ACOS(@SIN(LAT1)*@SIN(LAT2)+@COS(LAT1)
            *@COS(LAT2)*@COS(LON2-LON1))

F. HEADING

HEADING = @ACOS((@SIN(LAT2) - @SIN(LAT1)*@COS(DISTANCE))/
          (@SIN(DISTANCE)*@COS(LAT1)))

G. DETERMINE IF HEADING NEEDS TO BE REVERSED.

IF @SIN(LON2-LON1) < 0.0 THEN HEADING = 2 * PI - HEADING
```

List of formulas used to create a great circle spreadsheet.

There is nothing radically new in using a computer to generate great circle information. I have relied on articles by other authors to learn the basics of the computations. NS6N did a good job of explaining the trigonometry involved; even I can understand the principles.[1] The formulas for the computations, summarized in an accompanying table, should make the job of adapting the spreadsheet to other programs fairly easy.

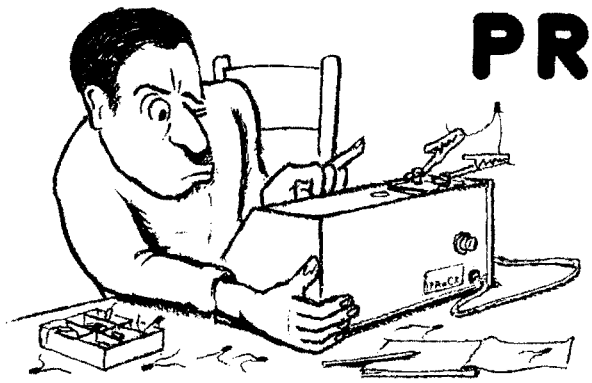
references

1. Van Brollini, NS6N, and Walter Buchanan, "DXing by Computer," *ham radio*, August 1984, page 81.

bibliography

1. Carl Wagar, VE3EKR, "Computerized Global Calculations", *73*, December 1977, page 106.
2. Dennis Bodson, W4PWF, and Bob Fenichel, WA2TMT/4, "Aim Your Antenna With a Micro," *73*, June 1977, page 108.

Article E **ham radio**



PRACTICALLY SPEAKING

Joe Carr, K4IPV

transmission lines and their typical ac responses

In an earlier column we looked at several parameters pertaining to radio transmission lines (some only rarely considered by Amateurs). We also discussed the step-function response of the transmission line. This month we'll talk about the ac response of the transmission line and some special cases of "looking into" impedance. Although some of this material is a little esoteric, my mailbag indicates sufficient interest for a column on the subject. Knowing this material can help you design antenna feed systems and matching systems based on transmission lines, and understand transmission line problems.

the ac response of a transmission line

When a CW rf signal is applied to a transmission line the excitation is sinusoidal (**fig. 1**), so it's useful to investigate the steady-state ac response of the line. The term "steady state" implies a sine wave of constant amplitude, phase, and frequency. When ac is applied to the input of the line it propagates along the line at a given velocity. The ac signal amplitude and phase will decay exponentially in the manner shown below:

$$V_R = Ve^{-r\ell} \quad (1)$$

where:

V_R is the voltage received at the far end of the line

V is the applied voltage

ℓ is the length of the line

r is the propagation constant of the line

The propagation constant (r) is defined in several equivalent ways, each illustrating its nature. For example, the propagation constant is proportional to the product of impedance and admittance characteristics of the line:

$$r = [ZY]^{1/2} \quad (2)$$

or, since $Z = R + j\omega L$ and $Y = G + j\omega C$, we may write:

$$r = [(R + j\omega L)(G + j\omega C)]^{1/2} \quad (3)$$

We may also write an expression for the propagation constant in terms of the line attenuation constant (a) and phase constant (B):

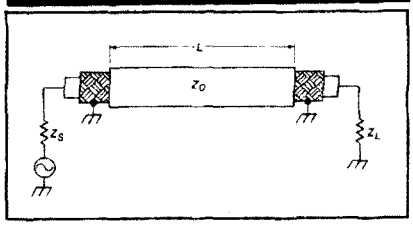
$$r = a + jB \quad (4)$$

If we assume that susceptance dominates conductance in the admittance term, and reactance dominates resistance in the impedance term (both usually true), then we may neglect the R and G terms altogether and write:

$$r = j\omega [LC]^{1/2} \quad (5)$$

We may also reduce the phase constant (B) to:

FIGURE 1



Coaxial transmission line excited by a sine-wave generator with source impedance Z_s and load impedance Z_L.

$$B = \omega [LC]^{1/2} \quad (6)$$

or, $B = \omega Z_0 C$ rad/m (7)

and, of course, the characteristic impedance remains:

$$Z_0 = [L/C]^{1/2} \quad (8)$$

special cases of looking into impedance

The impedance looking into a transmission line (Z) is the impedance presented to the source by the combination of load impedance and transmission line characteristic impedance. The equations that follow define the looking-in impedance "seen" by a generator or source driving a transmission line.

When the load impedance and line characteristic impedance are matched the definition is:

$$Z_L = R_L + j0 = Z_0 \quad (9)$$

The load impedance is resistive and equal to the characteristic impedance of the transmission line. The line and load are matched, and the impedance looking in will be simple $Z = Z_L = Z_0$. Other cases present different situations where Z_L is not equal to Z_0.

1. Z_L is not equal to Z_0 in a random length lossy line:

$$Z = (Z_0)\ \frac{Z_L + Z_0 Tanh\ (r\ell)}{Z_0 + Z_L Tanh\ (r\ell)} \quad (10)$$

where:

Z is the impedance looking in, in ohms

Z_L is the load impedance, in ohms

Z_0 is the line characteristic impedance, in ohms

ℓ is the length of the line in meters

r is the propagation constant

2. Z_L is not equal to Z_0 in a lossless

or very low loss random length line:

$$Z = (Z_o)\frac{Z_L + jZ_oTan\ (B\ \ell)}{Z_o + jZ_LTan\ (B\ \ell)} \quad (11)$$

Equations 10 and **11** above serve for lines of any random length. Special solutions are found for lines that are either integer multiples of half wavelength, or odd integer (1, 3, 5, 7, etc.) multiples of quarter wavelength. Some of these solutions are very useful in practical situations. For example,

3. Half-wavelength lossy lines:

$$Z = (Z_o)\frac{Z_L + Z_oTanh\ (a\ \ell)}{Z_o + Z_LTanh\ (a\ \ell)} \quad (12)$$

example 1

A lossless 50-ohm (Z_o) transmission line is exactly one-half wavelength long, and is terminated in a load impedance of Z = 30 + j0. Calculate the input impedance looking into the line (note: in a lossless line a =0).

solution:

$$Z = (Z_o)\frac{Z_L + Z_oTanh\ (a\ \ell)}{Z_o + Z_LTanh\ (a\ \ell)}$$

$$Z = (50\ ohms)\frac{30 + [(50)(tanh((0)(\pi))))]}{50 + [(30)(tanh((0)(\pi))))]}$$

$$Z = (50\ ohms)\frac{30 + [(50)(tanh(0))]}{50 + [(30)(tanh(0))]}$$

$$Z = (50\ ohms)\frac{30 + 0}{50 + 0}$$

Z = (50 ohms) (30/50) = **30 ohms**

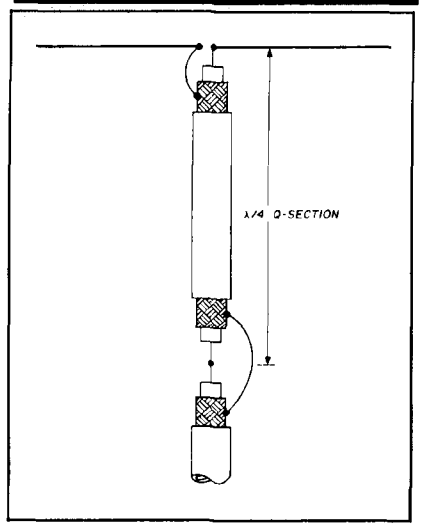
The preceding example shows that the impedance looking into a lossless or very low loss half-wavelength transmission line is the load impedance:

$$Z = Z_L \quad (13)$$

The fact that line input impedance equals load impedance is useful in certain practical situations. For example, a resistive impedance is not changed by the line length. So when an impedance is inaccessible for measurement purposes, the impedance can be measured through a transmission line that is an integer multiple of half wavelength.

The next case involves a quarter-wavelength transmission line, and those that are odd integer multiples of quarter wavelength (even integer multiples of quarter wavelength obey the half-wavelength criteria).

FIGURE 2



Quarter wave "Q-section" impedance-matching system.

4. Quarter-wavelength lossy lines:

$$Z = (Z_o)\frac{Z_L + Z_oCoth\ (a\ \ell)}{Z_o + Z_LCoth\ (a\ \ell)} \quad (14)$$

and,

5. Quarter-wavelength lossless or very low loss lines:

$$Z = \frac{[Z_o]^2}{Z_L} \quad (15)$$

Equation 15 shows an interesting property of the quarter-wavelength transmission line. First, divide each side of the equation by Z_o:

$$\frac{Z}{Z_o} = \frac{[Z_o]^2}{Z_LZ_o} \quad (16)$$

$$\frac{Z}{Z_o} = \frac{Z_o}{Z_L} \quad (17)$$

The ratio Z/Z_o shows an inversion of the load impedance ratio Z_L/Z_o, or stated another way:

$$\frac{Z}{Z_o} = \frac{1}{Z_L/Z_o} \quad (18)$$

We can deduce another truth about quarter-wavelength transmission lines from **eqn. 15**:

If

$$Z = \frac{[Z_o]^{1/2}}{Z_L} \quad (19)$$

Then

$$Z\ Z_L = [Z_o]^{1/2} \quad (20)$$

Which means

$$Z_o = [Z\ Z_L]^{1/2} \quad (21)$$

Equation 21 shows that a quarter-wavelength transmission line can be used as an impedance-matching network. Called a Q-section (fig. 2), the quarter-wavelength transmission line used for impedance matching requires a characteristic impedance Z_o (if Z is the source impedance and Z_L is the load impedance).

example 2

A 50-ohm source must be matched to a load impedance of **36** ohms. Find the characteristic impedance required of a Q-section matching network.

solution:

$Z_o = [Z\ Z_L]^{1/2}$

$Z_o = [(50\ ohms)(36\ ohms)]^{1/2}$

$Z_o = [1800\ ohms]^{1/2}$ = **42 ohms**

6. Transmission line as a reactance:

Reconsider **eqn. 11**, which related impedance looking in to load impedance and line length:

$$Z = (Z_o)\frac{Z_L + jZ_oTan\ (B\ \ell)}{Z_o + jZ_LTan\ (B\ \ell)} \quad (22)$$

In the case of a shorted line (Z_L = 0), the solution is:

$$Z = (Z_o)\frac{0 + jZ_oTan\ (B\ \ell)}{Z_o + j(0)Tan\ (B\ \ell)} \quad (23)$$

$$Z = (Z_o)\frac{jZ_oTan\ (B\ \ell)}{Z_o} \quad (24)$$

$$Z = jZ_oTan\ (B\ \ell) \quad (25)$$

Recall that:

$$B = \Omega Z_o\ C \quad (26)$$

Substituting **eqn. 26** into **eqn. 25** produces:

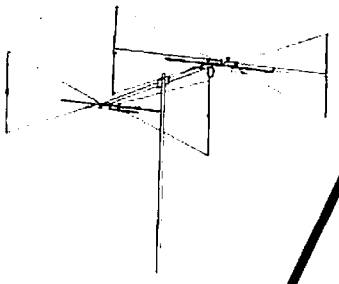
$$Z = j\ Z_o\ Tan\ (\Omega\ Z_o\ C\ 1) \quad (27)$$

or,

$$Z = j\ Z_o\ Tan\ (2\ \pi\ F\ Z_o\ C\ 1) \quad (28)$$

Because the solution to **eqns. 27** and **28** is multiplied by the j operator,

The HF4B "Butterfly"™
A Compact Beam
for 20-15-12-10 Meters



•Unique design reduces size but not performance
•No lossy traps, full element radiates on all bands.
•Retrofit kit for 17 meters coming soon.
•Turns with TV rotor
•Only 17 lbs

HF ANTENNAS FROM BUTTERNUT

Butternut Verticals

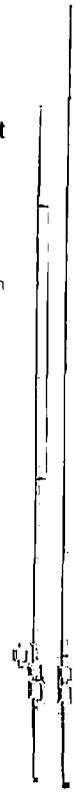
Butternut's HF verticals use highest-Q tuning circuits (not lossy traps!) to outperform all multiband designs of comparable size!

Model HF6V

•80 40 30 20 15 and 10 meters automatic bandswitching
•Add-on kit for 17 and 12 meters available now
•26 ft tall

Model HF2V

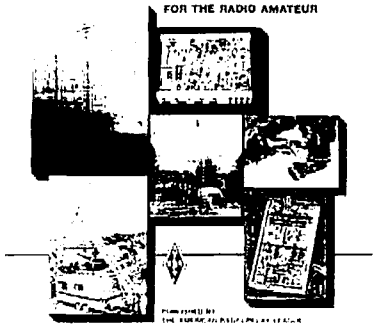
•Designed for the low band DXer
•Automatic bandswitching on 80 and 40 meters
•Add-on units for 160 and 30 or 20 meters
•32 feet tall, may be top loaded for additional bandwidth



For more information see your dealer or write for a free brochure

BUTTERNUT ELECTRONICS CO
405 East Market Lockhart, Texas 78644

THE 1988
ARRL
HANDBOOK
FOR THE RADIO AMATEUR

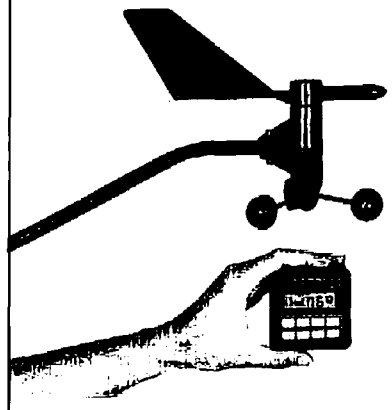


NEW EDITION

The 1988 ARRL Handbook For The Radio Amateur carries on the tradition of the previous editions by presenting 1200 pages of comprehensive information for the radio amateur, engineer, technician and student. Clothbound only. **$21** in the U.S., **$23** in Canada and elsewhere.

THE AMERICAN RADIO RELAY LEAGUE
225 MAIN STREET
NEWINGTON, CT 06111

WORLD'S SMALLEST
WEATHER STATION



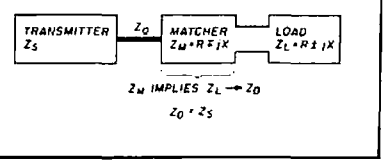
THE TW-2 MICRO WEATHER STATION INCLUDES A COMPUTER MODULE, THE AN-2 ANEMOMETER, AND 40' OF LEAD IN CABLE. FOR ONLY $159.95.

WIND SPEED	AUTO SCAN
WIND DIRECTION	METRIC / STANDARD
WIND CHILL	FOUR WAY POWER
WIND GUST RECORD	NICAD READY
TEMPERATURE	MOUNTING OPTIONS
HI/LOW TEMP RECORD	ONE YEAR WARRANTY

• • SATISFACTION GUARANTEED • •

MAGNAPHASE INDUSTRIES, INC.
MADE IN U.S.A. 1502 PIKE STREET N.W. AUBURN, WA 98001 M/C & VISA
ORDERS ONLY: 800-322-1502
INFORMATION: 206-735-0374 FAX: 206-735-9044

FIGURE 3

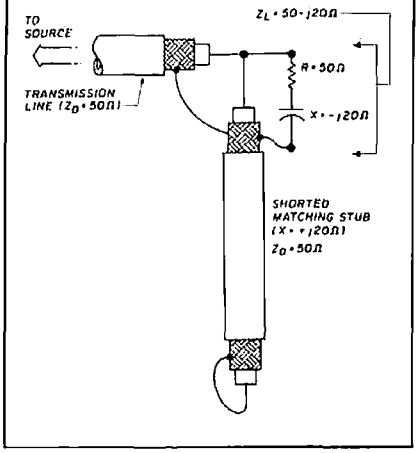


Elements of impedance-matching system.

the impedance is actually a reactance ($Z = 0 + jX$). Almost any reactance possible (within certain practical limitations) can be achieved by adjusting the length of the transmission line and shorting the load end. This fact leads to a practical method for impedance matching.

Figure 3 shows an unmatched load connected to a transmission line with characteristic impedance Z_0. The load impedance Z_L is $Z = R + jX$, in this case equal to 50 − j20 ohms. A complex impedance load can be matched to its source by interposing the complex conjugate of the impedance. For example, where $Z = 50 - j20$, the matching-impedance network will require an impedance of 50 + j20 ohms. The two impedances combine to produce 50 ohms. **Figure 4** shows a matching stub with a reactance equal in magnitude, but opposite in sign, with respect to the reactive component of the load impedance. Here the

FIGURE 4



Shunting matching stub "tunes out" reactance $-/+jX$.

stub has a reactance of + j20 ohms to cancel a reactance of − j20 ohms in the load.

A quarter-wavelength shorted stub is a stub concept that finds particular application in radio systems. (Microwave waveguides, incidentally, are based on the properties of the quarter-wavelength shorted stub.) The current is maximum across the short, but wave cancellation forces the current to 0 at the input terminals. Because Z = V/I, the impedance goes infinite when I goes to 0. This means that a quarter-wavelength stub has an infinite impedance at its resonant frequency, and acts as an insulator. The stub is in effect a "metal insulator."

conclusion

This month we looked at some of the more esoteric applications of transmission lines — proving once again that they are more than just wires for carrying rf to the antenna. In October we'll take a look at SWR.

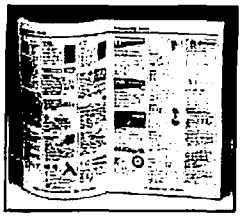
Attention "Poor Man's Spectrum Analyzer" fans: A company that makes a "budget" spectrum analyzer informs me that they'll make a loaner available for me to test. I'll let you know if the product is as good as the salesman claims.

This material is derived from Joe's forth coming Tab book, *Practical Antenna Handbook*. Joe Carr, K4IPV, can be reached at POB 1099, Falls Church, Virginia 22041; he'd like your comments and suggestions for this column.

Article F ham radio



211

FREE CATALOG!
Features Hard-to-Find Tools and Test Equipment

Jensen's new catalog features hard-to-find precision tools, tool kits, tool cases and test equipment used by ham radio operators, hobbyists, scientists, engineers, laboratories and government agencies. Call or write for your free copy today.
JENSEN® TOOLS INC.
Dept. HR
7815 S. 46th Street
Phoenix, AZ. 85044
(602) 968-6231
134

THE MULTIPLE RECEIVER SOLUTION

4 Channel Signal-to-Noise Voter
- Expandable to 32 Channel by Just Adding Cards
- Continuous Voting
- LED Indicators of COR and Voted Signals
- Built-in Calibrator
- Remote Voted Indicators Pinned Out
- 4½ x 6 Double Sided Gold Plated 44 Pin Card
- Remote Disable Inputs
- MORE

Built, tested and calibrated with manual
$350.00
Telephone interface now available
For more information call or write
DOUG HALL ELECTRONICS
Voter Department
815 E. Hudson Street
Columbus, Ohio 43211
(614) 261-8871
135

TEKTRONIX SCOPE

AN/USM-281C (mil-TEK 7603N11S) Oscilloscope with 8x10 cm display and two AM-6565 (7A15N11) single trace and one TD-1085 (7B53AN11) dual time base plug-ins. Performs to 65 MHz but 100 MHz mainframe accepts standard 7000-series plug-ins for full versatility. Deflection 5 mv to 10 V/div in 11 steps. Sweep 0.05 us to 5 S/div in 25 steps; delay to 0.5 s/div. 11.5x9.7x25.2, 52 lbs sh. Used-checked w/book $495
WRITE or CALL for probe and adapter availability!
Prices F.O.B. Lima, O. • VISA, MASTERCARD Accepted.
Allow for Shipping • Write for latest Catalog Supplement
Address Dept. HR • Phone 419/227-6573
FAIR RADIO SALES
1016 E. EUREKA • Box 1105 • LIMA, OHIO • 45802
136





THE HAM NOTEBOOK

bicycle mobile

I'm an avid bicyclist and ride about 22 miles each day. The roads in my part of the island of Hawaii are lonely, especially early in the morning. They stretch over the lava for considerable distances without any visible habitation except for some feral donkeys.

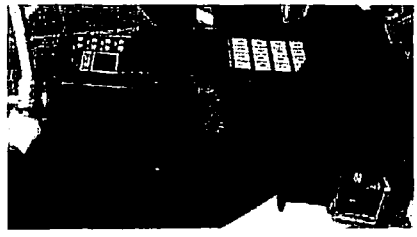
A number of times I've passed stalled vehicles way out in the boonies with worried and scared drivers peering hopefully at the passing traffic. At times like this I wished for a handheld so I could inform someone of their plight. But a standard 2-meter HT on a rough-riding 12 speed with 110 pounds of tire pressure wouldn't survive for very long.

I had an opportunity to examine all of the HTs out of their cases and noted quite a variation in construction. I needed something sturdy with a waterproof case to cope with the sudden tropical showers of Hawaii. Only one of all those I looked at met my specifications — the Yaesu FT 23 R.

My problem was to mount the HT (and an antenna) on the bike in a way that would make it easily accessible without requiring any separate clip-on mike or speaker. Placing it just below the handlebars allows for relatively easy speaking and listening when riding along.

I wanted to place the Yaesu, in spite of its obvious ruggedness, in a shock mounted container bolted to the handlebar stem. I built the container out of double-sided circuit board material soldered all around and lined with 3/8" plastic foam. A Velcro™ strap attachment holds the radio in place (see **photo A**).

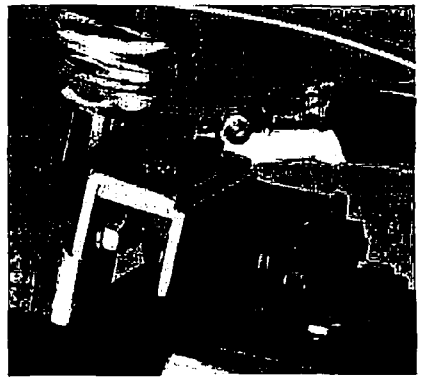
PHOTO A



Velcro strap holds radio in place.

During a visit to Silicon Valley I procured shock mounts from Hal Tech, a surplus parts supplier in Mountain View, California. I selected three shock mounts from their large inventory and used two on the HT box and one on the antenna. These were 1" x 1" round rubber items with isolated 1/4-20 studs protruding from each end. As you can see in photo **B**, they bolt through a short piece of 1" x 1" x 1/4" aluminum angle which is bolted, in turn, to the HT box. The whole assembly is then attached to a TV antenna "U" bolt that has been shortened to fit. This goes around the bike handlebar stem and, when tightened in place, provides a very strong mount for the radio.

PHOTO B



Bolt assembly for radio mount.

My next problem was the antenna. I wanted a half-wave device to avoid the requirement for a groundplane. AEA's Hot Rod proved to be ideal, particularly since it had a BNC connector for its base. Mag mounts would be useless on an aluminum bike. I cut a short piece of 1" x 1" x 1/4" aluminum angle and bent each end 90 degrees. One end was drilled to fit two BNC bulkhead connectors and the other to fit the rear bike carrier. I soldered on RG-8/X cable and sealed the whole assembly with epoxy putty, shaped to a pleasing appearance while it was still soft. The antenna assembly is shown in **photo C**.

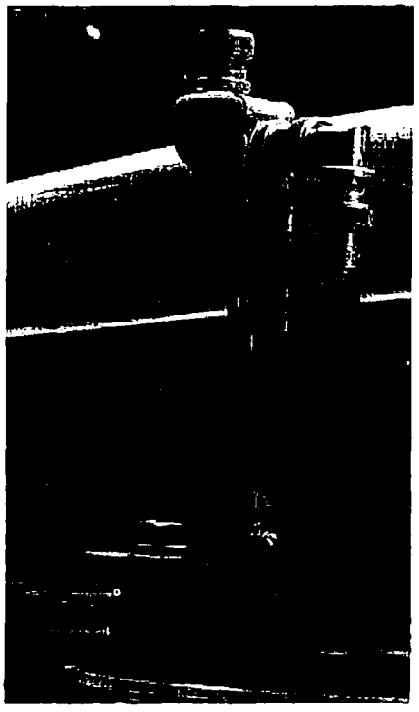
I attached the feedline to the bike's top tube with nylon ties and then to the HT with a right-angle BNC connector.

Bicycle Mobile has been in active, daily use for about 6 months; the only failure has been the antenna. The Hot

Rod rotated from vibration, and the coil broke loose from the connector. It was a simple matter to reconnect it. This time I didn't use heat shrink tubing around the coil but opted for two layers of rubber tape and one of plastic.

With this setup, I've been able to give assistance to stranded motorists. Their reactions are amusing when I wheel up and ask if I can call for help.

PHOTO C



Antenna assembly.

With relief, they look around for the hoped-for roadside phone. Of course there is no such thing on our bucolic island's roads, and some people become peeved until I explain that the little box under the handlebars is a ham radio. They feel much better when I tell them I can contact fellow hams on this or any other of the Hawaiian Islands by way of our trusty '7.02 repeater atop Mount Haleakala on Maui, the next island up the chain.

All I need now is a cape and mask to become the Lone Stranger on wheels. Who knows, maybe this unusual method of rescue will produce some new Amateur Radio enthusiasts!

William Schreiber, NH6N

intermittent reception due to lightning

When my receiver started to give me trouble in the form of intermittent reception, I would have been hard pressed for some clue as to where the trouble was but for a fortunate incident.

In checking an electric clock that had stopped running about the time my receiver had gone haywire, I spotted a hole burned into the middle of the motor coil. Only an induced lightning surge could have burned such a deep hole so far from any lead or terminal. This gave me the clue for where to look for trouble in the receiver.

The receiver antenna coil is held in place on the coil form by leads twisted so tightly that the antenna coil fits snugly around it. Not exactly good construction practice, as events proved.

Looking at the coil through a magnifying glass and under a bright light, I thought I saw a slight smudge or charred spot on the twisted leads. I would have paid no attention had I not been looking for just such evidence.

To keep the coil in place I doped it with some Duco cement. When the cement was dry, I unsoldered one lead and carefully unwound the twists. When I untwisted the charred part, I caught a slight glint of bare copper, which proved that my hunch was correct.

When I had the leads completely separated, I resoldered the one lead. The receiver has worked ever since.

John Labaj, W2YW

simple tower guards

After fencing in a large portion of my back yard to make a playground, I was soon aware of an unforeseen situation. My toddler son and his friends were using my two towers for gym sets. I'd seen articles dealing with this problem, but the solutions offered were, more often than not, bulky and unwieldy frameworks that attached to the tower legs. I wanted a simpler, more aesthetically pleasing solution to the problem.

attaching material to the tower

After examining the construction of my chain-link fence closely, I discovered the perfect way to secure my towers: I bought several feet of chain-link fabric. After securing one edge to a tower leg, I wrapped the tower with the fabric. After reaching the starting point, I cut the fabric to length by unweaving the appropriate fabric wire.

At this point, if you're patient enough, you can reweave both edges together to form a continuous loop of fencing around the tower or simply fasten the finishing edge to the tower leg.

materials — available, inexpensive

Chain-link fabric comes in widths measuring from 36 to 48 inches in 6-inch increments, and from 48 to 84 inches in 12-inch increments. Fabric wire standards are 6, 8, 9, 11, and 12 gauge. I recommend using at least a 9-gauge fabric in the 48-inch width. I chose fabric with a green vinyl coating because it's less conspicuous than the standard galvanized type. The vinyl-coated fabric costs about $2.00 per linear foot.

Aluminum tie wires, used by installers to fasten the fabric to the fence framework, are also ideal for fastening the fabric to the tower legs and across supports. A bag of 50 tie wires — more than enough for any single tower installation — costs about $3.00.

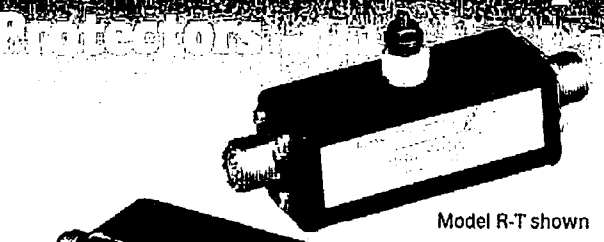
Materials may be purchased from local fence companies or through national outlet stores such as Sears.

Peter Bertini, K1ZJH

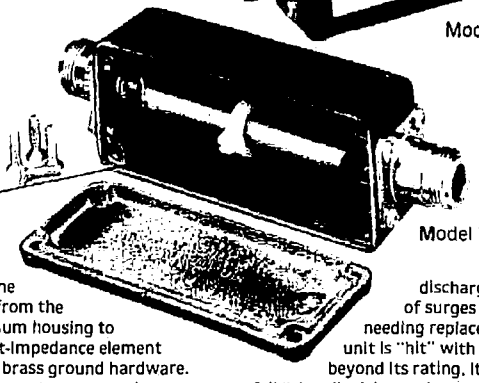
easy measurement of antenna currents

An rf current transformer is useful for measuring the current ratios in phased antennas, horizontals, and verticals. This transformer (usually only a few turns on a toroidal core) drives a rectifier and filter to create a voltage which can be calibrated against an rf ammeter.

Alpha Delta Transi-Trap®



Model R-T shown



Special shock absorber

Model R-T/N shown

- Quality. Built of the finest materials, from the heavy cast aluminum housing to the brass constant-impedance element and marine grade brass ground hardware. Only Amphenol connectors are used (instead of cheaper off-shore connectors found in other brands) for best frequency range and VSWR performance. The ceramic gas tube Arc-Plug® cartridge is protected by a unique custom-designed nylon shock absorber for best mechanical shock and vibration protection.
- Reliability. Original Transi-Trap units are still in daily use after providing years of continuous protection — from mountain top communications sites to ocean-going ships' radio rooms. The Arc-Plug cartridge discharges thousands of surges without needing replacement. If a unit is "hit" with a charge beyond its rating, it is designed to fail "short", giving an instant indication that replacement is needed. Other brands fail "open", leaving your equipment unprotected without you even knowing it.
- Performance. Standard "off-the-shelf" Transi-Trap units are used by every branch of the U.S. Military, many government agencies and several Western European countries. The Alpha Delta design is based on the U.S. NCS TIB85-10 Bulletin covering lightning and EMP protection for communications equipment.

Transi-Trap Protectors are designed for 50 ohms. Include a replaceable Arc-Plug cartridge and have UHF connectors (also available with N-type connectors for use through 1 GHz). *The low power models are most sensitive, best for RCVRS and XCVRS.*

MODEL R-T, 200 W through 500 MHz $32.95
MODEL HV, 2 kW through 500 MHz $35.95
MODEL LT, "T-type", 200 W through 30 MHz $22.95

At your Alpha Delta dealer. Or order direct in U.S.: add $3 for postage and handling. MasterCard and VISA accepted. Ohio residents add Sales Tax.

See Data Sheet for surge limitations.

MasterCard VISA

ALPHA DELTA COMMUNICATIONS, INC. AA

P.O Box 571, Centerville, Ohio 45459 • (513) 435-4772

current solutions to current problems

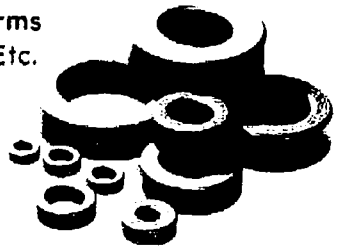
138

Iron Powder and Ferrite

TOROIDAL CORES

Shielding Beads, Shielded Coil Forms
Ferrite Rods, Pot Cores, Baluns, Etc.

Small Orders Welcome
Free 'Tech-Data' Flyer



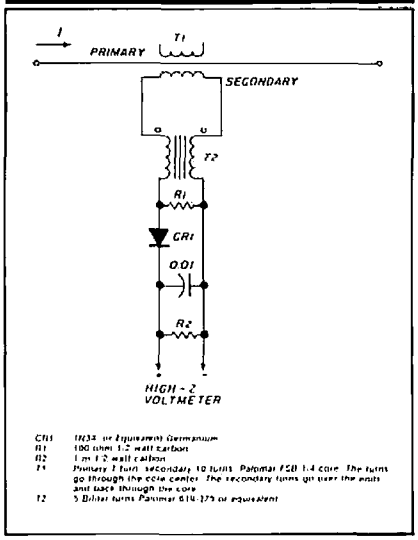
AMIDON Associates Since 1963

12033 Otsego Street, North Hollywood, Calif. 91607

139

To use this device, break the antenna feed, insert it through the core, and reconnect it to make the measurement; then disconnect it and go through the whole procedure at the next measurement point. A clamp on the transformer was constructed using Palomar Engineers' FSB 1/4 split bead (core), rated 1 to 1000 MHz; it worked great on the first try.

FIGURE 1



RF current transformer's output is read on voltmeter. The primary is the antenna feed under test. The split core opens up by compressing the clothespin-like device to accept the antenna feed wire.

I solved the need for some type of holder with an inexpensive plastic "snack bag" clamp, available at True Value hardware stores. It looks like a large clothespin after the side extensions are cut off. Wind the ten-turn secondary on one side of the core, then put both sides together and epoxy onto the plastic clothes pin. The other components are attached to the side of the pin to which the secondary is attached.

The values chosen allow low levels of drive to be used for minimum interference and reduced heating of the drive source.

The rf current transformer can also be used to check the wires in cases of RFI.

Bruce Clark, KO1F

A DTMF TONE SIGNALING CIRCUIT

Michael S. R. Moore, WV6A, 221 West Manly Avenue, Santa Ana, California 92704

Selective calling device alerts specific operators

Using Amateur Radio to contact a specific ham presupposes that he or she is monitoring the same frequency. This is usually accomplished by arranging schedules or coordinating by telephone. On 2 meters, members of a group usually monitor one frequency, often that of a local repeater. But unfortunately, if you're waiting for a call from someone in the group, you have to monitor that frequency. This can be tedious, especially if a rag-chewing session that doesn't interest you is in progress. What's needed is a signaling device that ignores all traffic except that which is intended for *you*.

The digital tone signaling circuit (DTSC) described here employs the same DTMF tones as those used for a similar purpose on the telephone system. Fortunately, many 2-meter radios are equipped with a touch-tone pad that can generate the full complement of dual tones.

The DTSC is a device that inputs an audio signal (for example, from the earphone outlet of a 2-meter HT) and searches the audio for DTMF tones. When detected, the tones are converted into a digital code and compared to a number previously stored in memory. When a sequence of input tones matches a sequence stored in memory, an alarm is generated.

The design shown here is arranged so that a four-digit number "dialed" within a 20-second time-out period causes an audible beeper and an LED to oscillate on and off at about half-second intervals. A five-digit number (with the first four numbers the same as above) causes the beeper and the LED to turn on without interruption. A six-digit number (again, all numbers must be dialed within the time-out period) will cause the alarm to clear.

Two of these units — each responding to a different set of numbers — have been in operation for several months. Each was built into a plastic case that accommodates an HT that receives its power from the unit; the unit's audio lead plugs directly into the radio. Tests show that the DTSC can determine the correct tones in noisy environments where audio signals are barely readable, in both simplex and repeater operation.

theory of operation

Essentially a Programmable Read Only Memory (PROM), the DTSC is loaded with a six-digit hexadecimal number by the operator who wants to activate the alarm. Audio output from a radio is fed to a DTMF tone decoder chip for comparison against the code in PROM. The alarm circuit is activated by the decoding counter output, which counts the number of correct digits received during a preset time interval. One incorrect digit causes the circuit to reset and wait for the correct sequence to be re-entered.

Twenty seconds after power up (see **fig.** 1), the 20-second timer, U1, times out, loading the 74LS193 counter, U2, with 0000. The counter is used to address the PROM (U3, a 74S287) and the PROM outputs a hex digit loaded at that address to U4, the 74LS85 comparator. An audio input from an HT or other radio is fed through a dc blocking capacitor to U5, a DTMF Decoder IC (Radio Shack Part No. 276-1303). Any valid DTMF tone pair will cause it to output a hex digit to the comparator; 7 microseconds later it will raise its strobe line. If the comparator sees a match between this hex number and the one that's output by the PROM, it outputs a 1 to the D flip-flop, U6 (a 74LS74), which is then clocked by the DTMF decoder chip data-valid strobe. This occurs only after the data is valid, allowing the comparator to set up before the strobe arrives. The data-valid strobe is also used to trigger the 20-second timer, releasing the loading pulse on the 74LS193 counter.

The 74LS74 flip-flop, U6, sets its *Q* bar output low, preventing the counter from being reset to zero and allowing it to advance by one count on the falling edge of the DTMF data-valid strobe. This happens when the tone pair is no longer being received. Since the

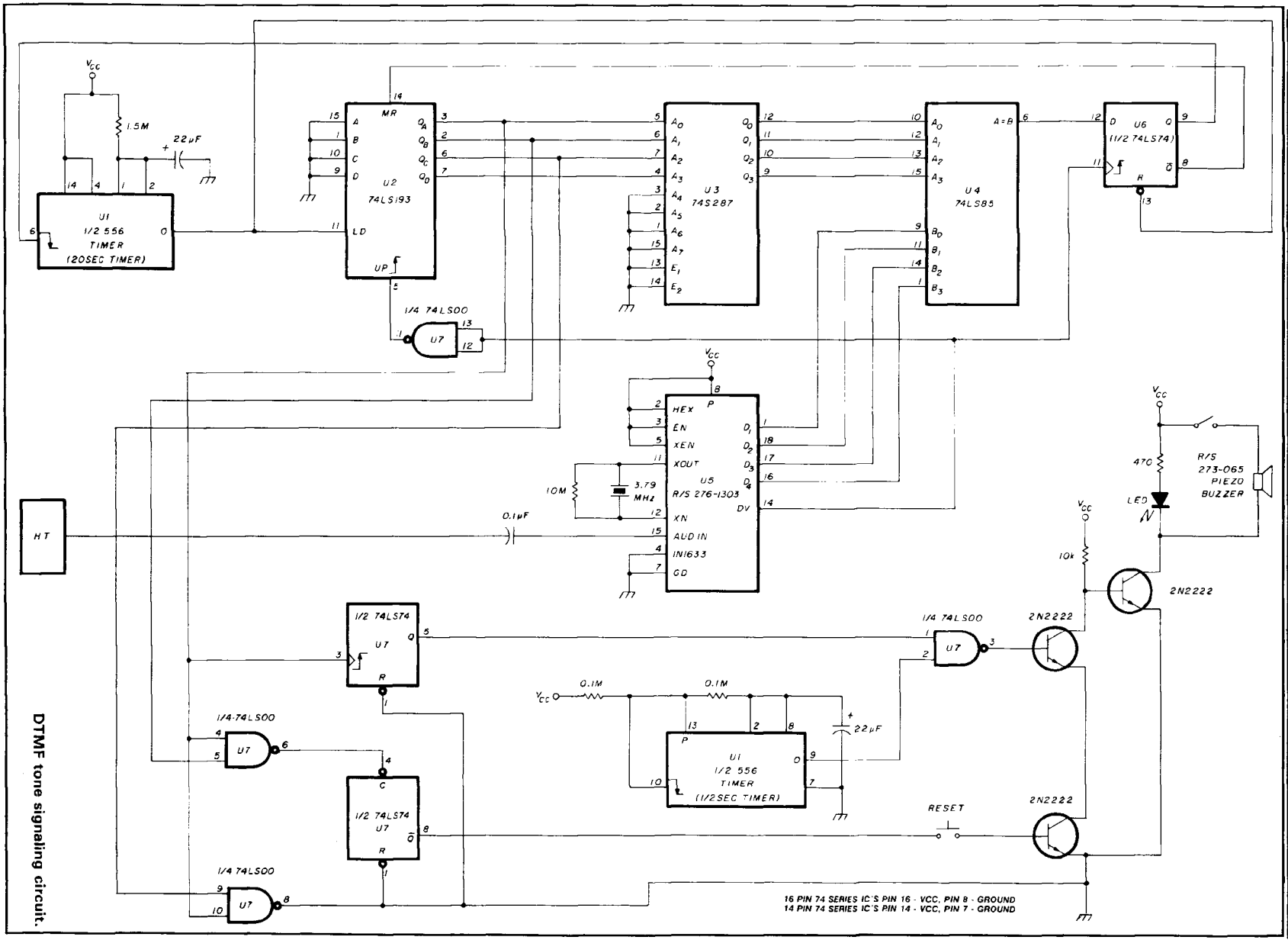
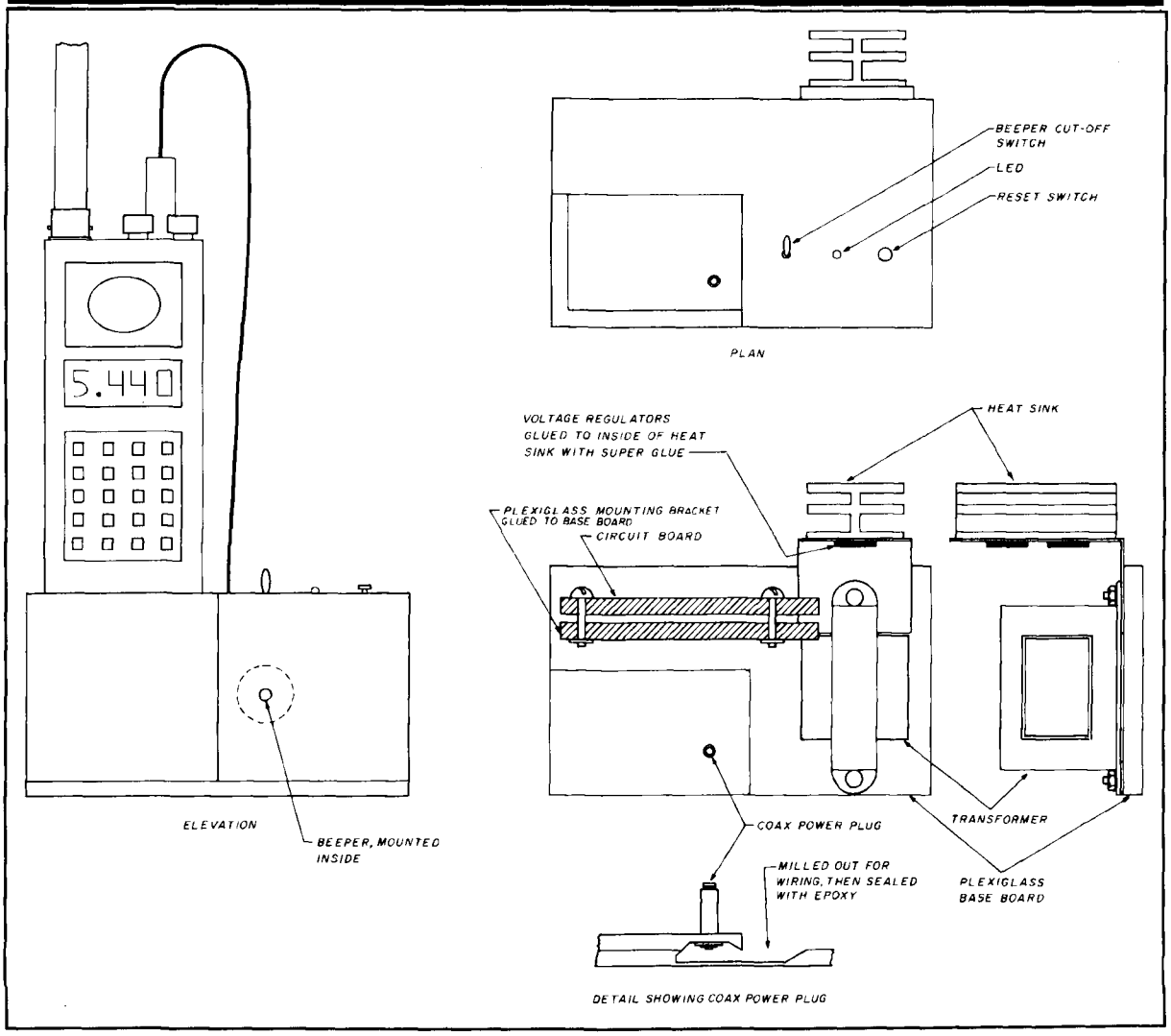


FIGURE 1

DTMF tone signaling circuit.

FIGURE 2



Mounting details for circuit board, voltage regulators, and other decoder unit components.

counter is now advanced, the output from the PROM becomes the new number for comparison.

If a number doesn't match the one in the PROM, the comparator will output a zero, causing the D flip-flop to go high, which in turn reloads the counter with 0000, the starting position address for the PROM. The code must now be re-entered from the beginning for the alarm to be activated.

After four correct numbers have been received, the second D flip-flop, U6, is clocked, enabling a 74LS00 gate of U7, to pass the half-second signal developed by the 556 timer, U1. The transistors are then arranged to flash the LED and sound the beeper. After five digits are received, the third D flip-flop, U8, causes the LED and beeper to turn on without interruption. A sixth correct digit will cause the LED and beeper to turn off.

It should be noted that *all numbers must be received* in the correct order within the time period (about 20 seconds) set by the 556 timer, U1. After this period the counter is reset and you must "dial" the correct sequence again. This reduces the possibility of accidental triggering. This could occur, for example, when a sixth tone follows five correct tones accumulated gradually throughout the day, causing the alarm to reset.

It's also possible to "advance the state of alarm" from oscillating on and off repeatedly to continuously on, giving some indication of who is calling if the five-digit code is restricted to one person.

construction notes

I built the circuit on perf board, using sockets for

all ICs. I chose perf board because I wasn't interested in making printed circuit boards for such a complex project, and because I wanted to allow for easy modification.

The power supply, which conserves battery life while you're monitoring the frequency, was built around a transformer salvaged from a discarded cordless telephone set and capable of delivering just under 1 amp at about 16 volts. Though this isn't enough to allow the HT to transmit at its 5-watt power level, the HT is somewhat inconvenient to operate when it's sitting in its stand. When the alarm is triggered, the HT can be quickly removed from its stand and operated from its battery.

Low-power Schottky logic was chosen because it was readily available. The circuit could be reworked, however, with any of the logic families; CMOS would be a good choice if battery-powered operation is required, as in a unit designed for portable or emergency operations. Any PROM could be used with suitable wiring changes, although circuit design is easier if at least a four-bit data type is used. It would be easy to program several different codes into the PROM using the unused address lines to select which code will be the active one. Since very little data is actually needed, a simple breadboard was set up with suitable power supplies to burn the PROM by hand.

The unit was built on a baseboard of Plexiglas™, which was bought as off-cuts from a plastics supply house at about a dollar a pound. It's easy to cut with a hand saw and glue with a solvent adhesive also available from the supplier. The case was made from the same material, with the back left open to permit air circulation.

Two voltage regulators — 5 volts for the logic and 12 volts for the radio power supply — were glued to a piece of aluminum with Superglue™. A piece of an old heat sink from a discarded TV monitor was added to increase the dissipation area (see **fig. 2**).

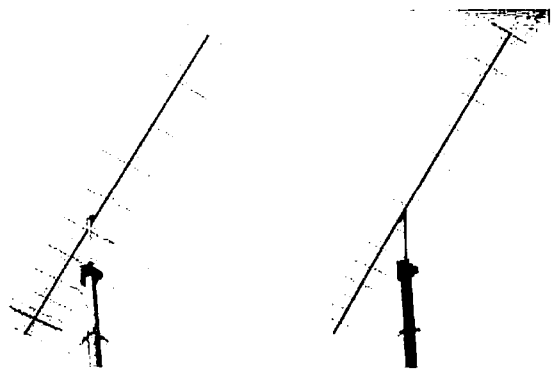
The Yaesu 209RH can be powered through a coaxial-type plug in the base of its battery pack. When inserted, this plug isolates the battery from the supply, allowing the radio to monitor using power from the DTSC only. The battery is not trickle charged, since doing so would limit the useful life of the NiCad™. The coax plug was glued into a piece of Plexiglas™, which was then glued onto the baseboard, which has a channel milled out for the 12-volt power supply wiring. The coax plug was positioned to engage as the radio is lowered into the DTSC. Using nuts, bolts, and standoffs, I mounted the circuit board to another piece of Plexiglass™ that was glued to the baseboard.

Article G ham radio

This article gives you the basics. A later piece will tell you how to program your PROM. *Ed.*

THE GENIUS OF K1FO
COMES TO 144 AND 220 MHz

ANNOUNCING THE
FO-12-144 AND FO-16-220



ANTENNAS FEATURE:
* HIGH FORWARD GAIN
* WIDE GAIN BANDWIDTH
* OUTSTANDING CLEAN RADIATION PATTERNS
* EXTREMELY RUGGED MECHANICAL DESIGN
* LOW VSWR

For details write to
RUTLAND ARRAYS
1703 WARREN ST.
NEW CUMBERLAND, PA. 17070
PHONE (717) 774-5298 7-10 P.M. EDT
Dealer inquiries are invited ✓ 142

You got it to work? Good!



NOW MAKE IT LOOK GOOD

Let DATAK be your designing partner. Use our dry transfer title sets to put that finishing touch to your custom project. Over 2200 titles plus alphabets and numbers insure that you'll have the words you need. Switch markings and dial plate arcs are in a companion set. Use DATAKOAT spray for complete protection. Sprays are not mailable.

948 Blk (949 Wht) 10 pt .105" Electronic Titles (24 sheets) $12.50
9581 Blk (9591 Wht) 12 pt .125" Electronic Titles (24 sheets) 12.95
968 Blk, Whi, Red assl. Meter dial & Switch Markings (12 sheets) 12.95
04177 DATAKOAT Gloss Spray (12 oz) 5.75
04178 DATAKOAT Matte Spray (12 oz) 5.75

Minimum order: $20.00 (add 7% shipping. NJ and CA also add sales tax)

WRITE FOR A FULL CATALOG AND SAMPLES TODAY
DATAK Corp. • 3117 Paterson Plank Rd. • N. Bergen, NJ 07047

✓ 143

product
REVIEW

Facsimile Software for MS-DOS computers and the PK-232 Data Controller

We live in the age of computer generated information and one of the biggest drawbacks is knowing how to take advantage of all the information available to us. The AEA PK-232 Data Controller's WEFAX capability gives you the ability to tap into the global network of weather reporting stations.

Maps and pictures, thousands of them in fact, are available twenty-four hours a day, seven days a week showing every aspect of the weather conditions. In fact there is so much available, it's sometimes tough to weed out what you don't want!

In days gone by, FAX receiving stations generated mountains of very expensive paper. Sometimes it would take an hour or two just to get one map. Obviously, this was very wasteful and there was a need for new technology

The latest technological breakthrough came with the advent of personal computers and specialized TNC's (like the AEA PK-232) acting as WEFAX receiving stations. This allowed ordinary graphics compatible printers to print WEFAX information; also a wasteful practice, as you are still running the printer. That's all been changed with the release of AEA's PK-FAX program.

The program works with all IBM and compatible computers to send and receive radio facsimile pictures through the PK-232 Data Controller. You can either print the pictures with a graphics compatible printer, display the picture on the screen of the computer, or save the images to disk. This saves oodles of paper!

Program setup is well covered in the instruction manual. Read and re-read the manual several times before attempting to use the program; it will save you plenty of time. First of all, make a copy of the disk to protect yourself from any serious faux pas. Next, set the configuration parameters for your system. The configuration menu is well explained and easy to follow, so this takes just a few minutes.

Since I covered the basics of receiving FAX in an earlier review, I won't repeat that information. Once you get the hang of it, it takes but a few seconds.

receive pictures

The PK-FAX program stores pictures to the computer's buffer and displays them on the computer screen. You can also retrieve images that have been stored on a data disk. One nice feature of the FAX program is that you can set it up to automatically receive images while you're not around and save them to disk for later use. If, for instance, you want the maps that are sent from noon to 2 pm on a Tuesday while you are at work. First, select the configuration menu and set the auto-save disk file prefix to Tuesday. Then establish an auto-save start time of 1200 and an auto-stop time of 1400. Press the escape key to return to FAX and the "F" key to turn on the stop-when-full feature. The contents of the buffer will automatically be saved to disk even if the transmitted stop signal is missed. The start signal that begins the next line will start to refill the buffer.

transmitting pictures

AEA recommends that you create images using one of the many graphics software packages available. The PK-232 is shipped with the transmit tones set at 1200 and 2200 Hz with a 1000 Hz shift.

To transmit, first read an image from disk to the buffer. Press the "T" key and you're transmitting a facsimile picture. It's really quite simple. Make sure you use the standards for transmission listed in the instruction manual. If you don't, sending pictures will be a very frustrating experience. AEA suggests a number of different transmission standards and time of transmission estimates as guidelines.

summary

That's all there is to it! While this program is easy to use, it facilitates the acquisition of a tremendous amount of information for the home FAX user. I am constantly amazed at the ability of these programs and the power that they bring into the Ham Shack. Just think what capabilities will be available from the software developers in the next few years!

de N1ACH

NEW
products

TH-55AT new 1200 MHz pocket

Kenwood introduces the TH-55AT — an all new 1200-MHz handheld transceiver. The TH-55AT uses the same accessories as the TH-25AT series HTs, with the exception of frequency-related accessories like antennas.

Features include:

- 1 watt high power, with optional PB-8; with standard PB-6 battery pack, 800 mW high. Low power is 100 mW.
- Frequency coverage 1258—1300 MHz.
- Front panel DTMF pad.
- Automatic Power Control (APC) circuit for reliable rf output and final protection.
- 14 memories; two for "odd split."
- Large multi-function LCD display.
- Rotary dial to select memory, frequency, CTCSS, and scan direction.
- T-ALERT for quiet monitoring. Tone Alert beeps when squelch is opened.
- Band scan memory scan.
- Automatic power off circuit.



Supplied accessories include a StubbyDuk, battery pack, wall charger, belt hook, wrist strap, and water resistant dust caps. Other accessories are available.

The suggested retail price of the new TH-55AT 1200 MHz Pocket Transceiver is $499.95. For details see your authorized Kenwood dealer or write: Kenwood USA Corporation, 2201 E. Dominguez Street, Long Beach, California 90810.

new software for Kenwood radios

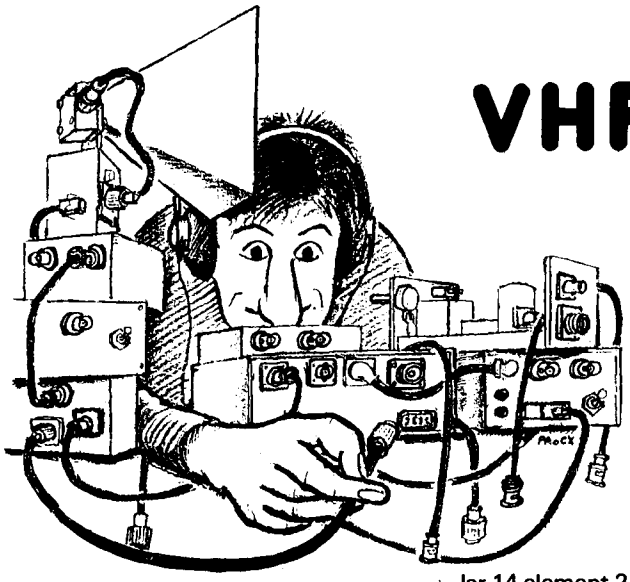
TS-COMM, a communications and control system for Kenwood radios, provides a computer software system to control Kenwood Amateur Radio products with IBM-PC/XT/AT series or true compatibles. Full control of frequency, mode, memory channels, and many front panel controls are supported.

System requirements are: IBM-PC, PC-AT or true compatible, DOS 2.1 or greater, 512K memory, one floppy disk drive, a serial communications port (COM1 or COM2), and 80-column printer.

Radio requirements: Kenwood IF-232 RS-232 interface/12 VDC P.S.; TS-940 requires the IF-10B, TS-711A/TS-811A require the IF-10A; TS-440/R-5000 require the IC-10.

The TS-COMM retails for $69.95 and is available exclusively from Ham Radio Outlet, 2620 W. LaPalma, Anaheim, California 92801.

Circle #301 on Reader Service Card.



VHF/UHF WORLD

Joe Reisert, W1JR

more loose ends

Judging from some of the comments I've received, many of you enjoyed February's "Loose Ends" column[1]. I thought I'd write another to answer all your latest questions.

antennas

This is always a popular topic; the one place where Amateurs can get the "most bang for the buck!" Whether you buy, build, or buy and redesign, there is something here for everyone.

It looks as if the May 1986 "VHF/UHF World" column[2] enccuraged lots of you to build simple high performance Yagis. I still get calls and letters on both the 2- and 6-meter beams featured in that column.

Some readers have built and used 2-meter beams for meteor scatter; many have used them on portable expeditions. Others have designed complete EME arrays. WA4NJP uses four of the 6-meter models on 50-MHz EME where he holds the worldwide DX record. W7IUV is very successful on 2-meter EME using sixteen of the 2-meter antennas in an array.

The 12-foot boom is convenient for portable operation. It's small and the boom is easily broken in half for travel. My son, AD1C, and I have both used this eight-element Yagi during several contests, to put out rare "grids" on 2-meters, and for portable EME using eight of them. Compared to the popular 14 element 2.2 wavelength 2-meter Yagi on a 15-foot boom length, its gain is only 0.75 dB lower with far less weight and wind load.

Even though I confirmed that there were no errors on the 2-meter Yagi element lengths in a subsequent column[1], I still get questions on the driven and reflector element lengths. They are correct as printed! But, as I pointed out in the original article[2], any changes in the feed system or mechanical changes (like through-the-boom mounting) could greatly affect the driven element length. This is of no real consequence because all you are trying to do is to obtain an impedance match. The driven element length, within reason, will not affect Yagi gain or pattern. One more thought: these antennas are optimized for a specific frequency. If you want to build one for the middle or upper portion of the 2-meter band (145-148 MHz), you should scale the element lengths and spacings. Failure to do so may seriously degrade the pattern.

Reduce each element by 0.400 inches for OSCAR use; the boom length, the distance between the reflector and the last director, should be 140 inches (versus 142 inches). For the upper FM band (147 MHz) shorten all elements by 0.750 inches and use a 139-inch overall boom length.

transmission lines and connectors

A lot of you have been interested in the newer type of low-loss transmission lines like Belden 9913 (or its equivalent). These coaxes usually have some air rather than being completely filled with a solid or foam dielectric. As a result, they are more susceptible to humidity and moisture.

Once moisture gets inside, it stays there and performance is permanently degraded. One solution is to carefully wrap the connectors with COAX-SEAL™ or Vapor-Wrap from Decibel Products, Inc. Another technique is to first wrap the connector with several layers of plastic electrical tape and then coat them with a layer of Scotchkote™ from the Electro-Products Division/3M Corporation.

Never use substitute connectors on 9913. Several companies now offer connectors specifically designed for 9913, albeit slightly higher priced than standard UG-21 types. These newer connectors are worth the money because they maintain constant impedance, are weatherproof, and don't require any filing or drilling of the center conductor.

You may remember that in the October 1986 "VHF/UHF World" column[3] I recommended using crimp connectors to decrease cost and assembly time. Some potential problems have surfaced with these since then.

Crimp connectors are fine if they use the normal base materials (like steel or brass) and are properly plated. But connectors made from aluminum base material, especially unplated ones, can be a disaster when used outdoors.

I recently took down a large array of 6-meter through 2304-MHz antennas for repair and upgrading. After many years of exposure to the elements and acid rain, they showed various states of wear or deterioration.

While disassembling these antennas, I took a careful look at the dozens of different connectors that I had used.

They were typically wrapped with plastic electrical tape or COAX-SEAL for 1 to 8 years. Some of the common types, especially those that were plated, showed little change except for occasional discoloration. But wherever I had used aluminum connectors, there were severe oxidation problems — even after only one year. In some cases they were so oxidized that they couldn't be removed without completely destroying the connector; this included several types of aluminum connectors like antenna mounted, cable crimp, and hard line. I recommend that you use aluminum connectors only indoors or where there is no other alternative.

After removing all the antennas, I took down all the associated transmission lines from the shack to the tower. They're about 130 to 150 feet long — tall trees require even taller towers away from the house! Each line was tested for VSWR and insertion loss at 50, 144, 220, 432, 903, and 1296 MHz; all results were carefully recorded.

I was truly astounded; every Andrew Corporation Heliax™ transmission line measured within or better than specification. Maximum attentuation on 135 feet of 7/8× ″ LDF at 1296 MHz was about 2.0 dB. All these transmission lines had copper conductors and Andrew Corporation connectors.

The 1/2- and 7/8-inch alumifoam coaxes were another story. Insertion loss was always higher than specification. One of the 7/8″ lines had an insertion loss that was higher than the equivalent length 1/2″ line! At 1296 MHz a 130-foot piece of 1/2″ alumifoam measured 5.8-dB insertion loss while a similar length of 7/8″ alumifoam measured 6.5 dB. In the future I'll do everything I can to avoid using aluminum coax or connectors in any form!

As I've been saying here for almost five years — buy good quality feedline. The initial cost may be higher, but it will give you a lifetime of pleasure with little or no deterioration. See reference 4 for recommended feedline types and selection tips.

propagation and new dx record update

My last column hadn't even gone to press before more VHF records were broken. There was some great propagation this spring in the Gulf states and along the Eastern seaboard.

During one Gulf coast opening in late April, 2-meter and 70-cm stations with only 10-50 watts and single Yagis were working from Miami, Florida (EL95) to western Texas (DM91) — about 1300 miles! On May 19th, stations as far north as New Hampshire and Massachusetts were treated to what is probably the first ever Caribbean 2-meter and 70-cm openings. VP5D on Providenciales (FL31US) in the Grand Turks Islands did the honors.

The best reported 2-meter DX was 1474 miles to W1JSM (FN43NC) and 1417 miles on 70 cm to W1RIL (FN42AH). From the reports I received, these contacts had all the earmarks of ducting because the stateside stations either had to be right near the coast or, if more than 15 miles inland, at elevated locations.

Spring 6-meter sporadic E propagation returned to North America on schedule, but this year the European openings to the United States came earlier and more often. To add to the excitement, several new countries were activated as 50-MHz privileges expanded in Europe.

If the unbelievable increases in solar activity continue, there may be some

TABLE 1

Some of the major VHF and above oriented publications. They are not listed in any particular order.

1. VHF/UHF and Above Information Exchange: c/o Rusty Landes, KAØHPK, P.O. Box 126, St. Mary of the Woods, Indiana 47876. Published monthly at $16.50 per year.
2. VHF Communications: Available from TimeKit, P.O. Box 22277, Cleveland, Ohio 44122. Published quarterly at $18.95 per year.
3. DUBUS (Dx Ueberreichweiten Bau von Geraten Uhf Shf Magazin): Available from KAØHPK (see item 1 above). Published quarterly at $18.95 per year.
4. 2-meter EME bulletin: c/o Gene Shea, KB7Q, 417 Staudaher Street, Bozeman, Montana 59715. Published monthly at $18.00 per year.
5. 220 Notes: c/o Walt Altus, WD9GCR, 215 Villa Road, Steamwood, Illinois 60103. Published 6 times yearly at $6.00 per year.

TABLE 2

This table shows some of the smaller society and club oriented publications. They are not in any particular order.

1. Midwest VHF Report: c/o Roger Cox, WDØDGF, 3451 Dudley Street, Lincoln, Nebraska 68503-2034. Published monthly at $10.00 per year.
2. MidWest VHF-UHF Society: c/o David Forbes, KD8FO, 1271 Jeanette Drive, Dayton, Ohio 454232. Published monthly at $5.00 per year.
3. Feed Point: The North Texas Microwave Society, c/o Wes Atchinson, WA5TKU, Rt. 4, Box 565, Sager, Texas 76266. Published 6 times per year at $12.00 per year.
4. Pack Rats' Cheese Bits: The Mt. Airy VHF Radio Club, c/o Doc Cutler, K3GAS, 7815 New Second Street, Elkins Park, Pennsylvania 19117. Published monthly at $5.00 per year.
5. Northeast VHF News: c/o Lew Collins, W1GXT, 10 Marshall Terrace, Wayland, Massachusetts 01778. Published 6 times per year at $3.00 per year.
6. East Coast VHF Society: c/o Dave Collins, K2LME, 709 Saddle River Road, Saddle Brook, New Jersey 07662. Published several times yearly at $10.00 per year.
7. Six Shooter, SMIRK Newsletter: c/o Ray Clark, K5ZMS, 7158 Stone Fence, San Antonio, Texas 78229. Published quarterly at $3.00 per year for SMIRK members.
8. West Coast VHF-ER: 560 W. Yucca Street, Oxnard, California. Published monthly at $10.00 per year.

6-meter F2 propagation as early as October 1988. With several stations reporting over 80 DXCC countries worked on 6-meters to date, can the first-ever VHF DXCC be far behind?

Two-meter sporadic E not only started earlier this season, but more openings seem to have been logged. The most significant opening was probably the one on June 6th — single-hop contacts were in progress between Alabama and Colorado at the same time that double-hop contacts were reported between the states of Alabama and Washington. So, unless I hear otherwise, we have a new 2-meter sporadic E record. At about 0245 UTC on June 6, 1988, several contacts may have bettered the DX record of 1980 miles set last June. Then at 0250 UTC, Dale Peterson, WA4CQG (EM72FO), worked Merle Cox, Kirkland, Washington (CN87VR), for a record breaking 2172 miles (3495 km). Both stations were well-equipped, with approximately 500 watts and antenna gains of 15-20 dBi. This contact took place on SSB and signals were not strong, but perfectly Q5. Congratulations to Dale and Merle. Can this record last very long? Stay tuned.

VHF/UHF microwave publications and societies

I have mentioned several times that to really know what's cooking on the VHF and higher frequencies, you should join a VHF, UHF, or Microwave group, or at least subscribe to one or more of the available newsletters. Many thanks to all those who sent me copies of their newsletter, especially to those who continue to do so. They are an excellent source of information.

I first ran a column on these publications in March 1985.[5] Since then there have been lots of changes; tables 1 and 2 list the latest newsletters and publications.

Table 1 shows the major VHF/UHF publications available by subscription and includes addresses, cost (where known), and frequency of publication. Contact the publisher directly for specific details. Table 2 is a partial list of the clubs and societies that have newsletters. Some are available on a subscription basis. Again, I recommend that you contact them directly. In addition to these publications, there are VHF/UHF columns in each of the major Amateur magazines. Professional publications are also available; see reference 5 for details.

summary

This month's column touched briefly on some your most commonly asked questions, discussed events in the VHF/UHF community, and listed some of the most popular VHF/UHF publications.

acknowledgments

Thanks to Pete Heins, K1FJM/4, and Bob Cooper, VP5D, for their input on some recent tropo openings. Thanks also for your topic suggestions; they're always welcome.

important VHF/UHF events

September 3-4	*International Region 1 VHF Contest (2-meters)*
September 10-12	*ARRL September VHF QSO party*
September 11	*New moon*
September 17-18	*ARRL 10-GHz Cumulative Contest, second weekend*
September 21	±2 weeks. Optimum time for TE propagation
September 25	*EME perigee*
October 1-2	*International Region 1 UHF/SHF Contest (70-cm and up)*
October 1-2	*Mid-Atlantic States VHF Conference, Warminster, Pennsylvania (contact WB2NPE/WC2K)*
October 9	*Predicted peak of the Draconids meteor shower at 0900 UTC*
October 10	*New moon*
October 20	*Predicted peak of the Orionids meteor shower at 1400 UTC*
October 23	*EME perigee*
October 22-23	*ARRL International EME Contest*

references

1. Joe Reisert, W1JR, "VHF/UHF World: Loose Ends," *ham radio*, February 1988, page 82.
2. Joe Reisert, W1JR, "VHF/UHF World: Optimized 2- and 6-meter Yagis," *ham radio*, May 1987, page 92.
3. Joe Reisert, W1JR, "VHF/UHF World: RF Connectors — Part II, *ham radio*, October 1986, page 69.
4. Joe Reisert, W1JR, "VHF/UHF World: Transmission Lines," *ham radio*, October 1985, page 83.
5. Joe Reisert, W1JR, "VHF/UHF World: Keeping VHF/UHFers up-to-date," *ham radio*, March 1985, page 126.

Article H **ham radio**

SATELLITE CITY
Communications for the Future
• Dan "KBOXC" • Dave "WBOSNM"
• Denise "YL" • Maline "XYL"
• Dan E "SOON" • Louis "KAOIPN"

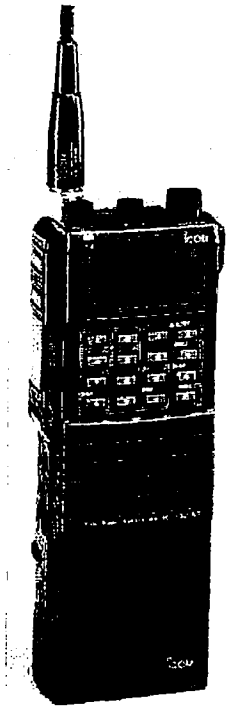
YAESU
H.F. EQUIPMENT
FT-736R 2m/430 Full Duplex 1749.95 Call
FT-747GX, 160-10m Xcvr 899.95 Call
FM-747 44.95 Call
FT-757 GX II Mark II Gen Cvg Xcvr 1129.95 Call
FP-757 GX PS 239.95 Call
FP-757 HD 299.95 Call
FC-757 AT 399.95 Call
FT- Call
MH-
Ant-tu
6M
99.95 Call
99.95 Call
440/
Call
FT-212 Packet Feature
FRG- 759.95 Call
FR 129.95 Call
FrA-7700 AC T 59.95 Call
FRT-7700 ANT NER 64.95 Call
FRG-9600 60-905 MHZ 699.95 Call
VU-9600 N.T.S.C. VID/CNVTR 25.00 Call
HANDI-TALKIES
FT23R 299.95 Call
FT23R/TT 334.95 Call
FT 33R 2m FM w/touchtone 344.95 Call
FT-33R/TT 220 MHZ FM w/T.T. 389.95 Call
FT-73R 4CW MHZ FM 309.95 Call
FT-73R/TT w/touchtone 349.95 Call
FTT4 DTMF 54.95 Call
FTS12 CTCSS 61.95 Call
NC29 Quick Change 84.95 Call
FNB10 60 9h@ 41.95 Call
FNB11 60 67 Call
FBA10 "A Call
FT109 RU 5 Call
F 95 Call
FT 95 Call
FT 72 5 Call
FNB-3/ Call
FNB-4/
NC1
PA 95 Call
CTC 5 Call
NOW Kantronics Packet In Stock
FT-290R/II 2 599.95 Call
FT-690R/II 6 All Mode 589.95 Call
FT-790 R/II 440 MHZ 799.95 Call
FT-4700 RII Dual Band TBA Call
FT-211 RH 2m 389.95 Call
FT-311 RM 220 MHZ 429.95 Call
FT-711 RH 440 MHZ 449.95 Call
FT-212RH Hi-Tech 2m 45w FM 459.95 Call
FT-712RH Hi-Tech 70cm 35w FM 499.95 Call
ALINCO
ALR-22T 2m 409.95 Call
ALR-22 HT 2m 429.95 Call
ALR-72 HT 400 MHZ 469.95 Call
ALD-24T Dual Band 637.95 Call
ALX-2T 2m 235.95 Call
ELH 230G 2 MTR Amp 30WT 90.00 Call
ELH 230D 2 MTR Amp + PreAmp 108.00 Call
ELH 260D 2 MTR 50 WT Amp 167.00 Call
ARRL BOOK LIBRARY
1-800-426-2891
METRO 612-754-1200
HOURS M-F 10-8 Sat 10-5
Prices subject to change and availability.
12581 Central Ave. N.E., Blaine, MN 55434

NEW products

ICOM dual band handheld

ICOM has just announced the new IC-32AT dual-band handheld. It features five watts of power output on each band, receives 138-174 MHz and 440-450 MHz, and transmits 140-150 MHz and 440-450 MHz.

Other features include full-duplex capability, 40 memory channels, programmable scan, and memory scan. There is also an optional UT-40



tone squelch unit which silently monitors a busy channel for your calls. When the pre-programmed subaudible tone is received, the unit beeps and the LCD flashes; it works like a beeper/pager.

The IC-32AT has DTMF keyboard access and a repeater input monitor. Priority watch monitors the call channel, memory channel, or all memory channels every five seconds while operating on another frequency. With the DIAL SELECT function you can change directly from 1 MHZ, 100 kHz digit, or the memory channel.

See your local ICOM dealer for details.

ICOM's IC-3210 dual band mobile

ICOM has introduced the IC-3210 25-watt, two-meter, 440-MHz dual band mobile. It measures only 5.5 inches wide by 2.0 inches high by 7.1 inches deep. Features include:

- Wideband Rx coverage of 138-174 MHz; Tx 140-150 MHz; receives and transmits 440-450 MHz.
- 20 memory channels with lock-out function.
- Two call channels — 1 VHF, 1 UHF.
- Programmable scan.
- Memory scan.
- Priority watch.

Also available are three new accessories for ICOM's base station transceivers: the AG-30 preamplifier for the 220 MHz IC-375A, the AH-610 dual band antenna (6M/10M) for the IC-575A/H, and the FL-100 500Hz CW filter for the IC-575A/H 6 meter/10 meter base station.

For more information about any of these products contact ICOM America, Inc., 2380 116*th* Avenue N.E., P.O. Box C-90029, Bellevue, Washington 98009-9029.

Circle #306 on Reader Service Card.

new logging program with text processor

Aerospace Consulting announces LOGWRITE™, an Amateur Radio logging program. It includes a split-screen feature allowing you to use your computer keyboard to jot down notes or to copy code while using the program to keep your log book records. To do this, LOGWRITE™ divides the screen into several regions. The top and bottom of the display consist of blocks into which the usual log book information is entered; the rest of the display shows text and program prompts. The program is entirely menu driven, works on all IBM PCs and compatibles, and is a fully-compiled program that runs by itself; it doesn't need to be run under basic. LOGWRITE™ can also print and edit records, search for call signs or prefixes, and automatically stamp time and date on contacts.

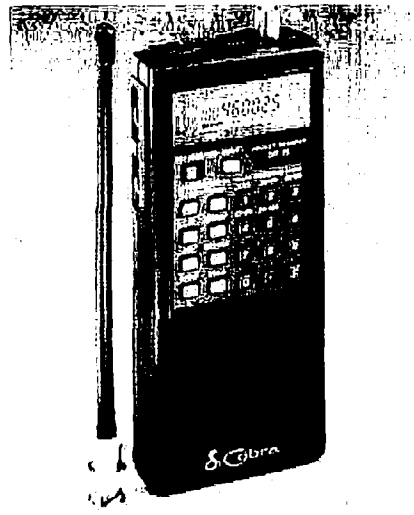
LOGWRITE™ is available from Aerospace Consulting, P.O. Box 156, Gwynedd, Pennsylvania 19436, for $24.95. (Pennsylvania residents add $1.50 for sales tax.) Place MasterCard and Visa orders by calling 800-345-4156 ext. 54, evenings and weekends.

Circle #307 on Reader Service Card.

100-channel handheld cobra scanner

Cobra has developed the first pocket-sized 100-channel scanner with 11-band coverage (including 10, 6, and 2 meters and 70 cm), keyboard programming, electronic digital tuning, and five memory banks. Each bank stores up to 20 frequencies and can be monitored separately or together in any combination at a scan speed of 15 channels per second. Channels can be grouped within the banks in any order for fast, easy access.

Automatic operating functions include auto and manual scan, automatic search, channel lockout, channel priority, selective scan delay, and channel hold.



The SR-15's backlit, six-digit LCD display shows the channel position and frequency readout during automatic and manual scan. The display also indicates the status of three operational modes (priority, lockout and delay) and the five memory banks.

The scanner is only 6" high x 2-3/4" wide x 1" deep with a weather-resistant case of anodized aluminum and high-impact ABS. Accessories include a flexible rubber antenna, rechargeable NiCd battery pack, ac adapter/charger, earphone, and carrying case. The SR-15 is priced at $299.95 (suggested retail).

For more information contact Cobra Consumer Electronics Group/Dynascan Corp., 6500 West Cortland Street, Chicago, Illinois 60635.

Circle #308 on Reader Service Card.

Correction for DMQ Technology

The loop antenna featured in the New Products section for August 1988 *HAM RADIO* can handle 1500 watts P.E.P. and is 39 inches in diameter. The antenna is wrapped with a heat shrinkable PVC, comes assembled and ready for use. For more information contact DMQ Technology, 221 Slater Boulevard, Staten Island, New York 10305.



THE WEEKENDER

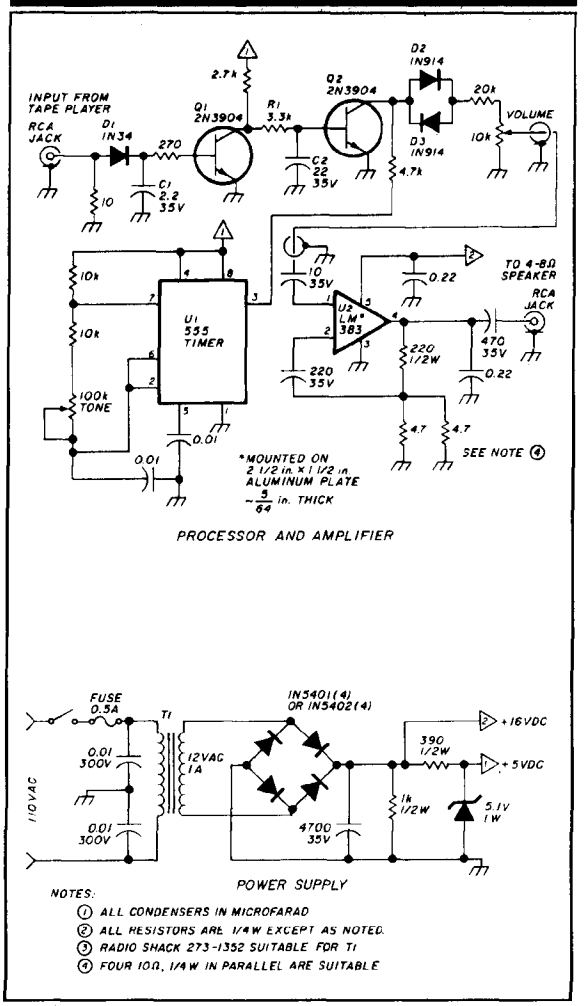
PROCESSOR FOR CODE TAPES

By Andy S. Griffith, W4ULD, 203 Lord Granville Drive, Rt. 2, Morehead City, North Carolina 28557

As a volunteer examiner (VE) I was concerned about the audio quality of many code tapes and audio amplifiers. In many cases the code tapes have tones that aren't clear, with objectionable background noise. Commercial amplifiers cause "thumps" which are sometimes audible at the beginning of each character on the tapes. The processor and amplifier described here eliminate all these problems. They provide quality audio from the worst of tapes and allow for adjustment of the code tone.

The simple circuit is shown in fig. 1. When a tone is input from the tape deck, diode D1 and capacitor C1 rectify and smooth the tone to a dc voltage which is amplified and inverted by Q1. Q1 drives gate Q2. The 555 timer (U1) generates a continuous tone which is applied to the collector of Q2 through a 4.7k resistor. When Q2 is "off", the tone is shorted to ground; when Q2 is "on", the tone passes to the input of audio amplifier, U2. Diodes D2 and D3 prevent leak-through of a residual tone when Q2 is off. The peak tone voltage must exceed 0.7 volts to pass to U2. The code characters are shaped by C2 and R1. As a result, the code coming out of U2 to the speaker is independent of the code quality and background noise on the code tape. The code sounds like a code practice oscillator with no background noise. Incidentally, I tried to key the supply voltage to U1 with the rectified input signal but was unable to eliminate clicks and shape the characters. I went to the gating circuit shown instead.

FIGURE 1

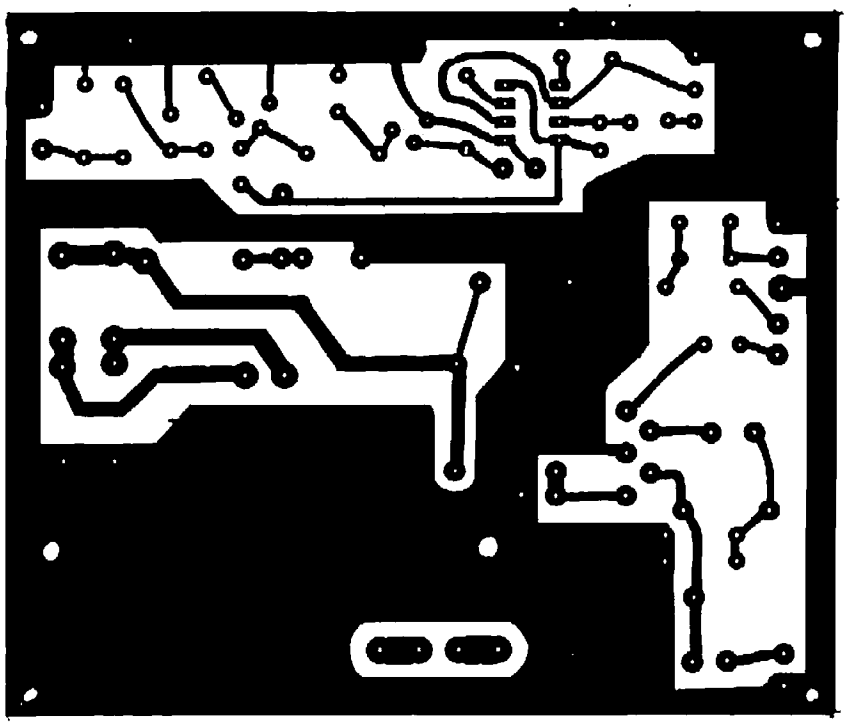


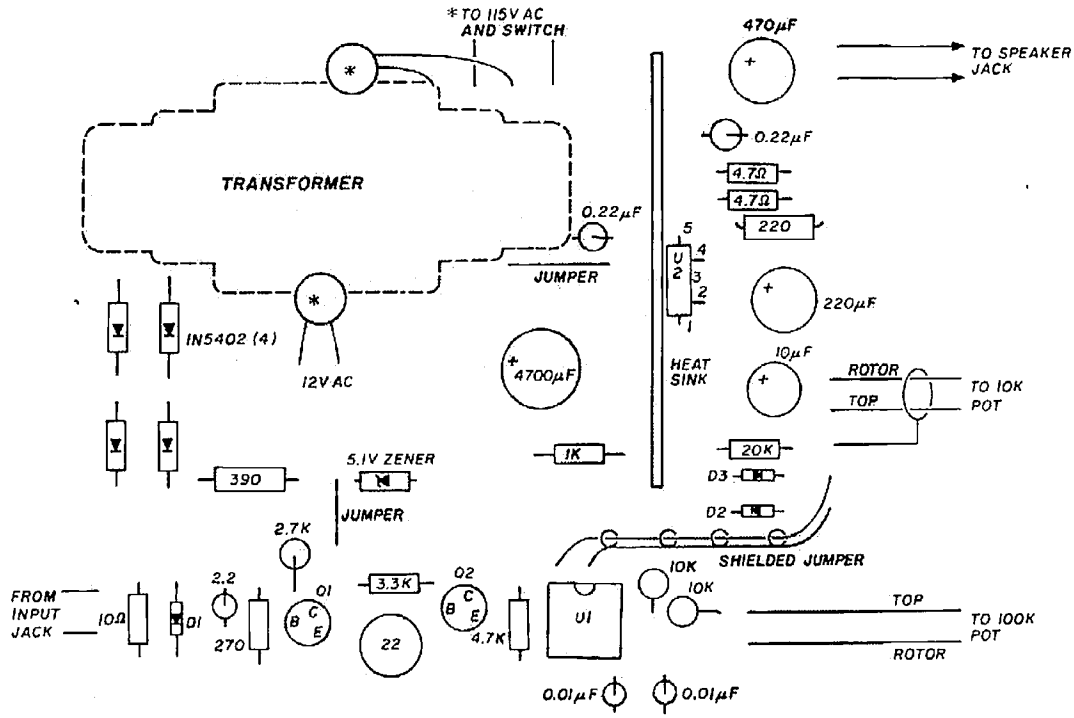
Schematic diagrams of the processor and amplifier and power supply circuits.

Except for the audio amplifier (U2), construction isn't critical. I used a single-etched circuit board (4-1/2" x 3-7/8") to mount *all components but the volume* control, tone control, and power switch (See fig. 2). These are mounted on the front panel of the 5-1/8" x 2-3/4" x 5-1/2" cabinet. The input and speaker jacks are mounted on the rear panel. The audio amplifier is mounted vertically on the circuit board and screwed to a vertical heat sink about 2-1/2" x 1-1/2" x about 5/64". Use thermal grease between U2 and the heat sink. It is important that all ground connections for U2 and its associated components be made close together; otherwise the amplifier will produce a hum. I believe that all components except the cabinet can be obtained from Radio Shack. Other suppliers list the cabinet in their catalogs. The circuit board can probably be reduced to fit a smaller cabinet.

Operation of the processor is simple. Use shielded cables to connect the processor to a suitable speaker and

FIGURE 2





Printed circuit board and parts layout.

Parts list

Resistors		*Diodes*	
1	10	1	1N34
1	270	2	1N914
1	2.7k	4	1N5401/1N5402
1	3.3k		
1	4.7k	*Zener diode*	
1	20k	1	1N3826/1N4733
2	10k		
1	220 1/2 watt	*Transistors*	
2	4.7	2	2N3904
1	1K 1/2 watt		
1	390 1/2 watt	*ICs*	
		1	555
Capacitors		1	LM383
1	2.2μ 35 volt		
1	22μ 35 volt	*Miscellaneous*	
2	0.01μ 35 volt	1	PCB
1	10μ 35 volt	1	Transformer (RS 273-1352)
1	220μ 35 volt	2	RCA jack
2	0.22μ 35 volt	2	Knobs
1	470μ 35 volt	1	Enclosure
2	0.01 300 volt	24"	Shielded cable
1	4700μ 35 volt	1	Switch
		4'	Power cable
Pot		1	.5A Pigtail Fuse
1	10k		
1	100k		

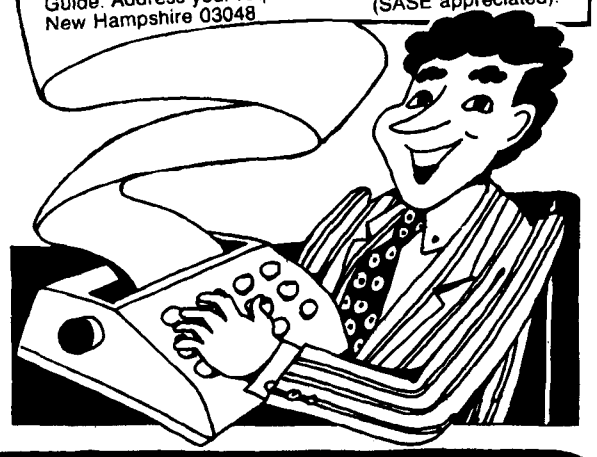
to the "ear", or output, of a tape deck. Turn on the processor. Set the tone control to about midscale and advance the volume about one-quarter. Insert a code tape in the tape deck and start it. Advance the volume control on the tape deck until you hear code from the speaker. Adjust the speaker volume and the tone with the controls on the processor. The best setting of the volume control on the tape deck should be just above the point where code is first heard in the speaker. The examinees at my VE sessions have commented on the high quality of code from the processor. I think you will find this a worthwhile project.

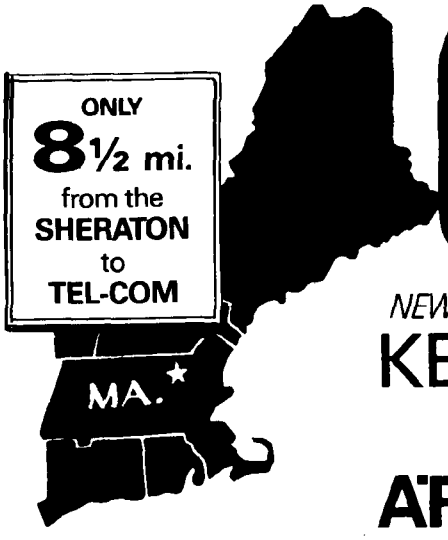
A pc board is available from FAR Circuits, 18N640 Field Court, Dundee, Illinois 60188 for $6.00 postage paid.

Article I **ham radio**

Invitation to Authors

ham radio welcomes manuscripts from readers. If you have an idea for an article you'd like to have considered for publication, send for a free copy of the *HAM RADIO* Author's Guide. Address your request to *HAM RADIO*, Greenville, New Hampshire 03048 (SASE appreciated).





TEL-COM Electronic Communications

NEW ENGLAND'S FACTORY AUTHORIZED SALES & SERVICE FOR
KENWOOD & ICOM

We Invite ALL VISITORS to the
ARRL NEW ENGLAND CONVENTION
AT BOXBORO

To COME SHOP New England's REAL HAM STORE

STORE SHOW HOURS Saturday 9 to 5 – Sunday 9 to 3

Offering
Special
SHOW
PRICES

Telephone 508/ 486-3400, 3040
675 Great Road, (Rte. 119) Littleton, MA 01460
1¾ miles from Rte. 495 (Exit 31) toward Groton, Mass.

TUNING INDICATOR FOR RTTY AND PACKET RADIO

By Bruce L. Meyer, W0HZR, 9410 Blaisdell Avenue South, Bloomington, Minnesota 55420

Circuit plus scope provides simple, useful displays

The tuning indicator in this article can enhance your RTTY/Packet operations. It provides rapid acquisition of the received signal with indications of signal strength, correct tuning, frequency shift, selective fading, and noise content — at a glance.

The device described here, an upgraded version of a previously published one[1], is made up of integrated circuits and synthetic inductors instead of vacuum tubes and low-Q wire-wound inductors. These enhancements improve the display and allow it to work with audio frequency shifts as narrow as 50 Hz. I call it the "X-display."

I have found that a simple receiving demodulator (terminal unit, receiving converter, or computer interface unit), when tuned properly to the received signal, can outperform a much more expensive unit that is not quite on frequency, especially in the presence of noise. To acquire a signal correctly, all the operator has to do is turn the receiver tuning dial until an upright "X" appears on the face of the CRT (cathode ray tube). When the signal is off-tune the X will lean or rotate to the left or to the right, depending on whether the frequency is too low or too high.

The *angle* between the legs of the X represents the amount of frequency shift. The *length* of each leg represents the instantaneous signal strength of the marking or spacing tone. With a nonfading signal, the legs will be the same length (see **fig. 1**). When a single tone is received, only one line will appear on the screen. During FSK the persistence of vision and the persistence of the CRT phosphor allow the marking and spacing tones, which appear as separate lines, to form the X.

As you tune the receiver to acquire the FSK signal the X pattern will rotate on the CRT face, and indicate correct tuning when the X is upright. At this point the user can compare the angle between the legs of the X with the calibration marks for the 170-Hz or 200-Hz frequency shift previously placed on the CRT face. **Figure 2** illustrates incorrect tuning of the receiver. **Figure 3** shows a frequency shift that is too narrow; too wide a shift is shown in **fig. 4**. If the transmitted signal contains extraneous frequencies, like those caused by power supply hum or keying transients, the legs of the X will be wide. There can even be two or more X patterns superimposed and slightly offset in angle from each other (see **fig. 5**). This is an indication of incidental FM.

The heart of the X-display device is a simple RLC series network (**fig. 6**). This network discriminates between signal frequencies above and below its series resonant frequency, but does not appreciably affect the amplitude of the received signal as measured across the inductor. The amplitudes of the marking and spacing frequencies may be measured or viewed independently of each other.

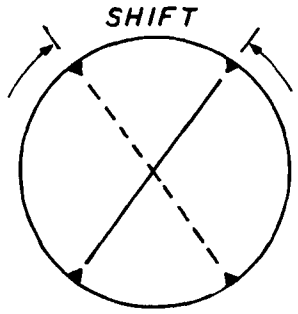
Component selection for the RLC network isn't difficult. The inductor should have as high a Q as possible, within reason. If the Q is too low (20, for instance), the CRT will display an ellipse rather than a line. The ellipse is useful but slightly more difficult to interpret. I tried several commercial toroidal inductors in the range of 88 to 800 mH. None had a Q of more than 20 at the chosen display center frequency of 2210 Hz. Fortunately, a synthetic inductor called a "gyrator" is available.[2] I recommend one consisting of two inexpensive operational amplifiers, one capacitor, and several resistors. It has a Q close to 200 and is ideal for this application. (More about this circuit later.)

type of scope required

It should be emphasized at this point that it is not necessary to construct a custom oscilloscope in order to obtain the X-display. Any oscilloscope with separate inputs for X and Y deflection may be used, provided that the oscilloscope amplifiers have sufficient gain and that the controls can be locked in place when frequency calibration has been made.

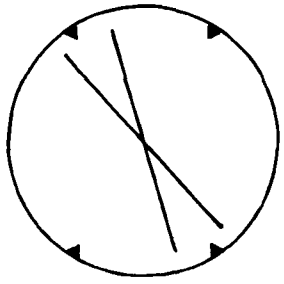
A block diagram showing the major elements of an X-scope adapter for an existing oscilloscope or modification thereof appears in **fig. 7**. The major elements shown are the input amplifier/equalizer, the discriminator, the horizontal output buffer amplifier, and the vertical output buffer amplifier.

FIGURE 1



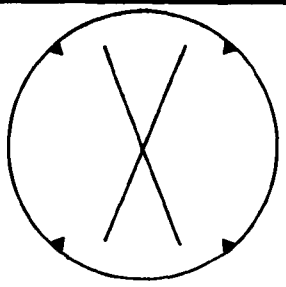
Line slopes with audio frequency.

FIGURE 2



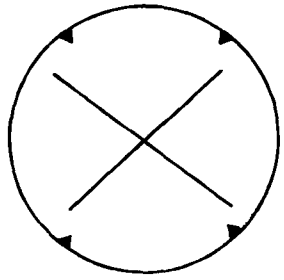
Receiver is mistuned.

FIGURE 3



Shift is too narrow.

FIGURE 4



Shift is too wide.

The buffer amplifiers of **figs. 8** and **9** are not needed if you simply wish to feed the discriminator outputs to the corresponding inputs of an existing oscilloscope. If, however, the oscilloscope is modified to leave only the deflection amplifiers, the buffer amplifiers may be needed to provide isolation and gain.

Another consideration is the power supply. Both positive and negative voltages in the range of 9 to 15 volts are needed by the X-scope adapter. These may already be available in a solid-state scope. The current requirements are modest, less than 50 mA. If a vacuum tube scope is used, you'll have to construct or buy a power supply. The parts cost shouldn't exceed $20.00.

The resistor in the discriminator circuit serves two purposes: first, it provides the entire voltage drop between the signal source and the LC network at resonance; second, it prevents a high voltage from appearing across the inductor at resonance. The size of the resistor isn't critical. It is selected so that there is little difference among the voltages across the inductor at, above, and below resonance. The voltage across the inductor will naturally increase with increasing frequency. For that reason it is desirable to use a low-pass de-emphasis network ahead of the RLC discriminator. This network or equalizer causes the signal trace on the CRT screen to have a nearly constant vertical deflection throughout the frequency range of interest. A simple equalizer circuit appears in **fig. 10**.

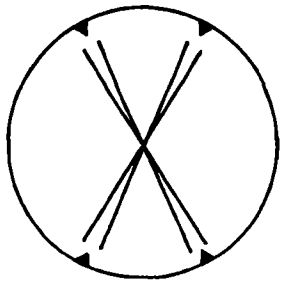
The discriminator circuit of **fig. 11** consists of R_5, C_2, and the gyrator circuit shown separately in **fig. 12**. The gyrator is the L of the RLC network described above.

theory of operation

Those familiar with oscilloscope presentations will recognize a sloping line display as representing two alternating current signals that are either in phase or 180 degrees out of phase. This is exactly what happens in an RLC circuit containing a lossless capacitor and lossless inductor. Above resonance the voltage across the inductor is greater than the voltage across the capacitor. Below resonance the voltage across the capacitor predominates. At resonance the voltages are equal and opposite in phase, so they cancel and there is no horizontal deflection of the CRT beam. The net voltage across the inductor and capacitor in series is compared by the oscilloscope with the voltage across the inductor alone, resulting in the in-phase or out-of-phase presentation on the CRT screen.

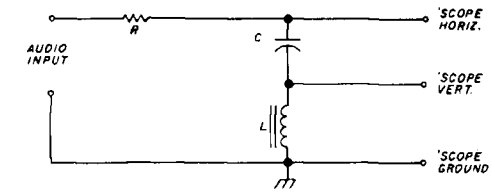
The equalizer circuit in **fig. 10** consists of a 741 or equivalent operational amplifier with capacitive negative feedback, whose time-constant complements that of the FSK discriminator network to provide an essentially flat frequency response for the vertical deflection system.

FIGURE 5



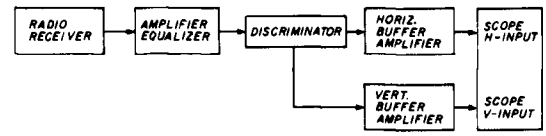
Incidental FM.

FIGURE 6



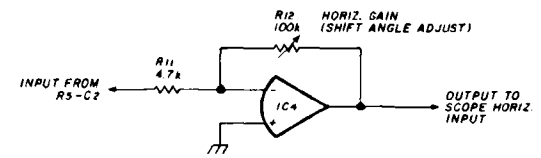
Basic RLC network.

FIGURE 7



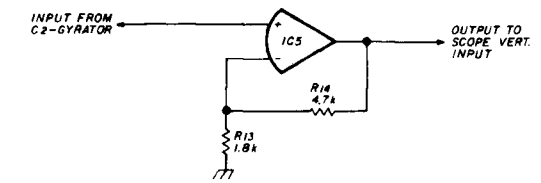
System block diagram.

FIGURE 8



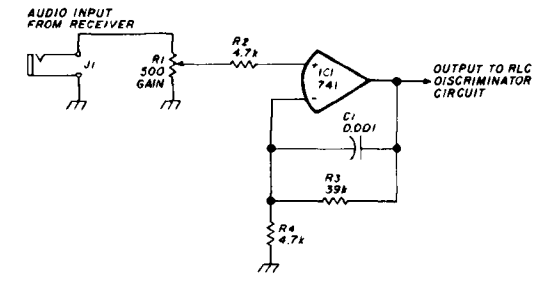
Horizontal buffer-amplifier.

FIGURE 9



Vertical buffer-amplifier.

FIGURE 10



Audio Equalizer (de-emphasis network).

The gyrator circuit of **fig. 12** is made up of two 741 operational amplifiers which comprise the integrator coupled with a negative impedance converter. The combination appears at the input as an inductor with a Q approaching 200. An ordinary variable resistor in the gyrator circuit is used to vary the effective inductance and to tune the FSK discriminator to the proper resonant frequency.

This is a good place to mention that very few if any inductors are lossless, although capacitors may be nearly so. A lossy inductor will not provide an ac voltage drop that is exactly 180 degrees out of phase with the voltage drop across the capacitor. The internal resistance of the inductor will cause a small phase shift which will result in the display of an ellipse instead of a straight line. The higher the Q of the inductor, the closer the trace will resemble a straight line. For this reason the use of a synthetic inductor or gyrator is recommended.

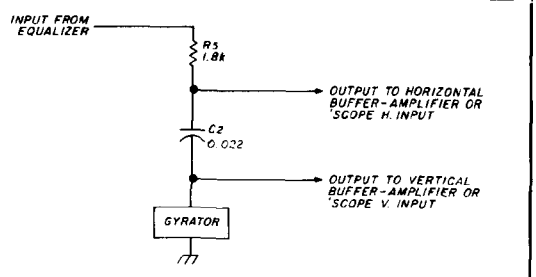
The horizontal buffer amplifier of **fig. 8** is used to set the gain of the horizontal deflection circuits. It isn't required if the scope has a high-gain horizontal amplifier in place. The amount of gain used controls the width or angle of the legs of the X displayed.

The vertical buffer amplifier of **fig. 9** provides a modest amount of gain but its main role is to isolate the gyrator from resistive loading, which would degrade its Q. If a commercial oscilloscope with a very high input impedance is used, the vertical buffer amplifier circuit may not be required. The scope input may then be connected directly to the junction of C_2 and the gyrator circuit.

construction project

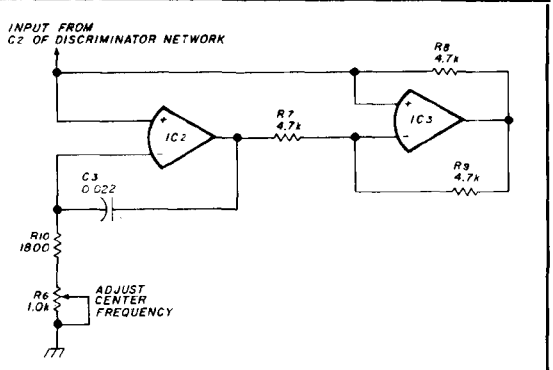
One problem that arises in dedicating a lab scope to this application is that the beam tends to burn the phosphor of the CRT face so that a permanent X pattern appears, with a dark spot at the crossing point. This does not drastically affect the screen of the scope

FIGURE 11



RLC discriminator network.

FIGURE 12



Gyrator circuit (synthetic inductor).

but is somewhat unsightly. After one has used the lab scope to verify the utility of the system, it may be a good idea to purchase an inexpensive one at a flea market and modify it as required to incorporate the FSK discriminator. Audio oscilloscopes like those built from kits can be found for as little as $15.00.

An advantage in modifying an inexpensive scope is that its gain controls can be locked in place to preserve the frequency calibration. It doesn't matter whether the scope has vacuum tubes or transistors in its deflection circuits, as long as the user can adapt the FSK discriminator to the deflection circuits and provide the correct power supply voltages. The scope's timebase circuits can be removed or disconnected.

I chose to build a complete X-scope with cabinet, low- and high-voltage power supplies, solid-state deflection circuits, and a 2AP1 CRT. The discriminator and amplifier circuits described above were placed on a small purchased pre-perforated circuit board. The circuit board had copper pads at every hole. I used No. 30 wire-wrap wire for interconnection because the insulation can withstand soldering heat. The insulation is tough; I recommend that you use a stripping tool designed for No. 30 AWG wire.

After the circuit was assembled, the circuit board was mounted on standoffs above the oscilliscope chassis. The circuit was then wired into the rest of the scope circuits. This technique should be adaptable to almost any scope foundation or chassis.

calibration

For the initial calibration of the completed X-scope circuit, an audio signal generator is needed that can generate the marking and spacing tones used by a modem/interface unit/terminal unit (typically 2125 and 2295 Hz for 170-Hz shift). You'll also need a tone midway between the two frequencies. The indications of the X-scope will be only as accurate as the frequency source.

The tone may be taken from the audio signal across the voice coil of a loudspeaker, at a comfortable listening level, and applied to the input of the equalizer circuit. While watching the CRT display you must adjust the gyrator inductance by varying R_6 until the selected center frequency (2210 Hz) causes a vertical trace to appear on the CRT face. At this point there is no horizontal input to the deflection circuits. The input frequency is now changed to either the marking or the spacing tone to observe the angular deflection from vertical. It should be between 30 and 40 degrees. If it is not, you must adjust the horizontal gain to achieve the desired angle. By alternately applying marking and spacing tones to the input, you can cause the CRT trace to lean alternately to the right and left, or vice versa. The slope depends on the vertical amplifier phasing with respect to that of the horizontal amplifier. The connections of one set of deflection plates, or the inputs of one set of differential amplifiers in the oscilloscope, can be reversed for opposite slope.

The next step in calibration is to mark the face of the CRT or its protective screen with the positions of the marking and spacing tone traces. Use marker pen, crayon, or masking tape arrows. Be sure to center the beam before starting. Carefully log all oscilloscope gain control settings and check them for reset ability. If you find that you cannot reset the controls precisely, you may be a candidate for a custom scope unit that doesn't have variable gain controls.

using the X-scope

Once the display is calibrated, disconnect the audio signal generator and connect the output of the radio receiver in its place. Tune the receiver to a radio teletypewriter signal or to a packet radio signal and observe the display. During frequency shift signal reception the CRT screen will display an X-shaped pattern with some faint lines between the legs of the X. These faint lines represent the transient response of the receiver and the discriminator and should be ig-

complete parts list

Capacitors	
C1	0.001 μF, 10% Mylar
C2,C3	0.022 μF, 10% Mylar
Resistors	
R1	potentiometer, 500 ohms (not critical)
R2,R4,R7, R8,R9,R11, R14	4.7k, 1/4 watt, 5%
R3	39k, 1/4 watt, 10%
R5,R10,R13	1.8k, 1/4 watt, 10%
R6	potentiometer, 1k
R12	potentiometer, 100k
Integrated circuits	
U1,U2,U3, U4,U5	Type 741 operational amplifier, or equivalent. (Dual or quad units may be used also.)

nored. When the signal is properly tuned in, the X will be upright and centered. If the receiver is tuned too high or too low the X will tilt to the left or to the right. *The frequency shift is indicated by the angle between the legs of the X only when the X is upright and centered.* The length of each leg of the X will vary with signal strength. Often with selective fading one leg or the other of the X will shrink to nothing. If copy is good at this time, you have a superior receiving demodulator.

You can observe signal quality of the FSK transmitter by examining each leg of the X. If the trace is a narrow line it indicates that a pure tone is being received. If the trace is wide at the ends, or if more than two traces are seen, the sending station may have a problem wth contact bounce or with modulating tones that contain hum or other spurious frequencies. A common problem is ac ripple in the dc power supply output to the AFSK signal source at the transmitting station. This hum causes incidental FM which rides atop the FSK signal in the rf output of the SSB transmitter.

Atmospheric noise or QRM will confuse the display by generating Lissajous patterns. It is important that noise levels be kept low if the display is to be correctly interpreted. It is very helpful to use the narrowband filter of the receiver, or a bandpass audio filter between the receiver and the X-display to remove signals that are outside the audio spectrum of interest. In doing so you must be careful not to use too narrow a filter as the marking or spacing signal may be cut off.

conclusion

I have found the X-scope to be a valuable and fascinating addition to the equipment in the ham shack. Not only can it be used to monitor 170 or 200-Hz frequency shifts, but if the center frequency is changed and the horizontal gain reduced, it can monitor 425 or 850-Hz shifts as well. There are some interesting signals to be found between the ham bands, like multiplex, which may produce four traces on the screen of the X-scope.

Anyone who is reasonably skilled in the construction of analog circuits should have no difficulty building the X-scope. I'll be happy to answer questions you may have; please enclose an SASE.

references

1. Bruce Meyer, WØHZR, "FSK Tuning Indicator," *CQ*, The Radio Amateurs' Journal, May 1956.
2. "Filter Design Techniques," *The Lenkurt DEMODULATOR*, May 1975.

Article J ham radio

Half-Square QRV-DX Monobanders
Work DX with No Tower and No Amplifier.
Cut noise, cut near sigs, build DX sigs, kill QRM.
10 Meters 15 Meters 20 Meters 40 Meters
$29.95 $39.95 $49.95 $69.95
Coax Feed, Broadside Pattern, Low Profile, Ready to Use
Highest DX Gain per Dollar
To order add $5 Postage & Handling
Infopack $1 by 1st class mail.
AntennasWest
Dept H, Provo, UT 84603-1144 (801) 373-8425

Folded Broadbander *Bi-Band Dipoles & Slopers*
Unique folded design shortens and creates broad resonance in two bands. Leg is 70'for FB 160/80 and 35' for FB 80/40. Infopack $1 by 1st class mail.
•Full Legal Power •No Caps or Coils •Never Corrodes •Fully Insulated •Ready to Use
HalfSloper Dipole •Fast Mount •Coax Fed •Tough
FB 80/40 $59.95 $79.95
FB 160/80 $69.95 $99.95
Specify CW or SSB & Add $5 P&H
AntennasWest
Dept H, Provo, UT 84603-1144 (801) 373-8425

QuickKit G5RV, Loop, & Dipole Kits
Fast & Easy to Build
• Everything included
• Failsafe visual instructions
• No measuring / cutting
• Finish antenna in minutes
Quality Components
• Presoldered Amphenol PL259
• Kinkproof Superflex wire
• Fully insulated, wx sealed, no-corrode, low noise design
Fastest Antennas in the West
AntennasWest
(801) 373-8425
• Full Size G5RV $34.95
dipole coverage 80-10
• Half Size G5RV $24.95
dipole coverage 40-10
• Quarter Size G5RV $19.95
dipole coverage 20-10
• Marconi Adapter kit $ 4.95
• Antenna Launcher kit $14.95
• 200' Dacron 250# line $11.95
• Loops, dipoles, feedlines, etc.
Add $5 Shipping & Handling
Catalog $1 by 1st class mail
Dept H, Provo, UT 84603-1144

170

GIVE YOUR EARS A BREAK ON **HF!**


Auto-Kail HF Alert
• Encoder / Decoder use with SSB / CW / FM / AM. Novice to extra • Encoder sends 2 strings of "dits" at precise speed. 225 combinations • Decoder mutes speaker until signaled • Built-in speaker • Alarm enable output • Mobile mounting bracket • 13.8 VDC • Easy to hook up • Great for mobile to base use. HF traffic nets, etc. Send or call for complete info
MoTron Electronics
695 W. 21st Ave.
Eugene, OR 97405
Introductory price:
$129.95
(S4 Shipping/Handling USA)
Orders 1-800-338-9058 Info (503) 687-2118
TLX 984794

171

Electronic Repair Center
Servicing
Amateur **Commercial Radio**
The most complete repair facility on the East Coast.
Large parts inventory and factory authorized warranty service for Kenwood, Icom and Yaesu.
SEND US YOUR PROBLEMS
Servicing "Hams" for 30 years, no rig too old or new for us.
HAMTRONICS, INC.
4033 Brownsville Road
Trevose, Pa. 19047
215-357-1400

Minimizes weight, wind resistance, to realize gain from height

a five-band dipole

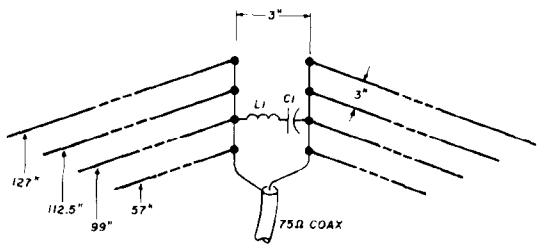


fig. 1. Electrical dimensions of the 5-band dipole. L1 and C1 are used only for 2-meter matching. C1 is 2.2 pF ceramic and L1 is 3 turns of No. 12 wire, 2-inch inner diameter, 1 inch long, air wound.

The advantage of antenna height is well known to DXers. Frequently a light-weight low-gain antenna at a respectable height will outperform a higher gain antenna of lower elevation. My new QTH was in a heavily wooded area and there was an 85-foot fir tree close to the shack. Comparisons of two antennas, one at treetop and one 40 feet lower, demonstrated the height advantage.

I gave much thought to the development of a design that would perform effectively at treetop level on five of my favorite bands: 15, 12, 10, 6, and 2 meters. A beam that would cover all of these bands was ruled out as too cumbersome and heavy to be carried to the top of an 85-foot tree. I feared the frequency separation of the 15, 12, and 10-meter bands would be inadequate for a conventional trap antenna to perform efficiently. Weatherproofing the traps would also be a problem. I resorted to a technique I had seldom used in the past — parallel dipoles. Results have been quite satisfactory; spaced only 3 inches apart, parallel dipoles on these bands seem to perform with almost no interaction.

Because the antenna is horizontal it was necessary to use a rotator. The pattern is bidirectional so only 180° of rotation is needed, and it is possible to get by with as little as 90°. The antenna is light in weight (26 pounds) and has low wind resistance; only a small rotator is needed.

A schematic of the five-band dipole is shown in **fig. 1**. The four dipoles are adjusted for half-wave resonance at frequencies of 21.25, 24.9, 28.6, and 50.3 MHz. The 10-meter dipole works as a 5/2 wavelength dipole on 2 meters where it has a theoretical gain of 3 dB over a half-wave dipole. A serious 2-meter operator would probably want to add elements for a four- or five-element Yagi to the same boom and feed it with a diplexer such as shown in **fig. 2**. Alternatively a small 2-meter Yagi could be added to the same mast. However, my own results with only 3 dB of gain have been quite satisfactory on 2 meters. Admittedly, my elevation (5300 feet ASL) has been a contributing factor.

A purist would want to feed this antenna with a 1:1 balun. Measurements with a current probe[1] have shown the rf current on the outside of the coax to be quite small compared with the dipole current, so no balun was used.

The 2-meter impedance of the 10-meter dipole turned out to be capacitive at my operating frequency near 144.2 MHz. It was necessary to cancel this reactance with a shunt inductance. In order not to upset the feed impedance of the lower frequency dipoles, the inductance was placed in series with a series-tuned circuit, resonant at 144.2 MHz. The series-tuned circuit inductance is in series with the matching inductance and the two inductances can be combined into a single larger inductance of about 0.8μH. The series

By Fred Brown, W6HPH, Box 73, Palomar Mountain, California 92060

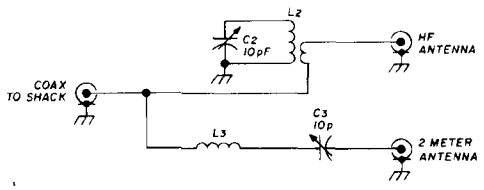


fig. 2. This 2-meter diplexer will permit use of the same coax feeder for a separate 2-meter antenna without compromising performance on either 144 MHz or the lower bands. Both L2 C2 and L3 C3 are carefully tuned to 144 MHz. The link on L2 is one turn. L2 and L3 can be 4 turns No. 18, 1/2-inch diameter, 3/8 inch long.

dowel, I planed off the corners of 1-1/2 inch square stock to form an octagonal cross section; and then planed the eight corners further to make a force fit into the PVC pipe. This is not easy without a power planer. You can use 1-3/8-inch diameter closet pole purchased from any lumber yard. Leave 18 inches empty on each end to receive 69-3/4 inch lengths of 1-inch PVC to make an overall length of 258 inches, or 0.46 wavelength at 21.15 MHz. The "1-inch" PVC has an outside diameter of about 1.32 inches, so wrap these lengths with vinyl tape as shown in **fig. 3** to build up the diameter and form a snug fit inside the 1-1/2 inch PVC pipe.

Teflon™ insulators are used at the far ends of the

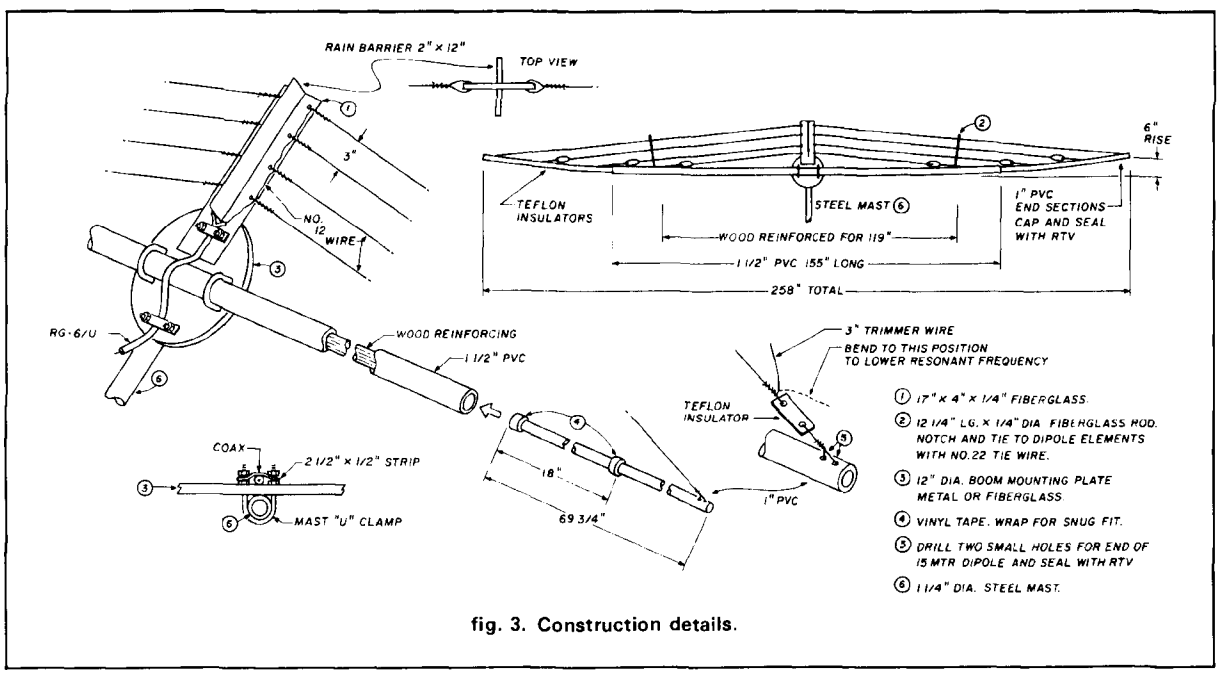


fig. 3. Construction details.

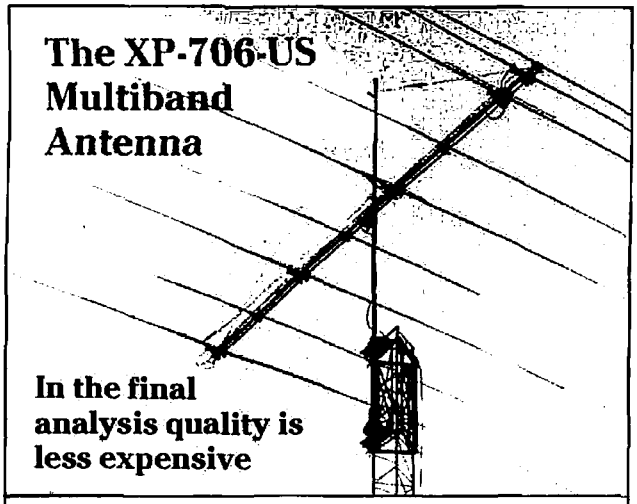
capacitance of 2.2 pF is too small to upset the resonant frequencies of the lower bands.

construction

As you can see in **fig. 3**, the antenna is made almost entirely of material that is frequently discarded at construction sites. By salvaging such material the total cost can be held to almost nothing. The dipoles are made of No. 12 (.081 inch diameter) solid copper wire stretched between ends of a slightly bowed nonmetalic boom. The center 155 inches of the boom is made of 1-1/2 inch PVC pipe commonly used in construction. PVC pipe of this diameter is not rigid enough for a boom length this size so I reinforced the center 119 inches with 1-1/2 inch wood dowel. To make the 6, 10, and 12-meter dipoles, but the 15-meter dipole ends are secured directly to the PVC boom in order to minimize the overall length. PVC has a bad reputation as an rf insulator[2], but at a power level of 65 watts I could detect no temperature rise in the PVC at the 15-meter dipole end points. If you comtemplate high power, I recommend checking for temperature rise before raising the antenna.

For the 12-inch diameter boom mounting plate I used high-strength plastic. Metal or fiber glass can also be used. If you use plywood, weatherproof it by painting with hot tar before assembling.

Seal all holes in the boom with RTV and cement end caps to the far ends of the 1-inch PVC sections. As an extra precaution against moisture accumulation,



The XP-706-US Multiband Antenna

In the final analysis quality is less expensive

The unique design of the XP-706-US antenna system gives you MONOBAND PERFORMANCE in a Multiband beam. The antenna *USES NO TRAPS* of loading coils that rob power and limit bandwidth. Sommer Antennas use the FULL surface area of the elements on ALL bands.

Our commitment to use only the finest materials insures that your investment will last for years. Our system uses a Double rectangular boom, CAST aluminum element mounting brackets, all stainless hardware and a high power balun.

Monoband performance on a *Multiband* beam is yours when you move up to Sommer the last beam you'll have to buy. We believe Sommer is your best antenna value when compared to the construction and performance of other multi and monoband antenna systems.

H.J. Theiler Corp.
P.O. Box 5369
Spartanburg, SC 29304
(803) 576-5566

SOMMER

173

W6SAI BOOKS

published by Bill Orr, W6SAI and Stu Cowan, W2LX

BEAM ANTENNA HANDBOOK
Completely revised and updated with the latest computer generated information on BEAM Antenna design. Covers HF and VHF Yagis and 10, 18 and 24 MHz WARC bands. Everything you need to know. 204 illustrations. 268 pages. © 1985 Revised 1st edition.
RP-BA — Softbound $11.95

SIMPLE LOW-COST WIRE ANTENNAS
Primer on how-to-build simple low cost wire antennas. Includes invisible designs for apartment dwellers. Full of diagrams and schematics. 192 pages. ©1972 2nd edition
RP-WA — Softbound $11.95

ALL ABOUT CUBICAL QUAD ANTENNAS
Simple to build, lightweight, and high performance make the Quad at DX'ers delight. Everything from the single element to a multi-element monster. A wealth of information on construction, feeding, tuning and installing the quad antenna. 112 pages. ©1982. 3rd edition.
RP-CQ — Softbound $9.95

THE RADIO AMATEUR ANTENNA HANDBOOK
A wealth of projects that covers verticals, long wires, beams as well as plenty of other interesting designs. It includes an honest judgement of gain figures, how to site your antenna for the best performance, a look at the Yagi-Quad controversy, baluns, slopers, and delta loops. Practical antenna projects that work! 190 pages. © 1978. 1st edition.
RP-AH — Softbound $11.95

Please enclose $3.50 for shipping and handling VISA

ham radio magazine BOOKSTORE
GREENVILLE, NH 03048 (603) 878-1441

drill 1/4-inch drainage holes through the underside of both pipes 17 inches from each end of the 1-1/2 inch PVC.

pruning

Make final adjustments at least 10 feet above ground. You should get SWR curves similar to **fig. 4**. The final dipole lengths should be very close to those shown in **fig. 1**. **Figure 3** shows a trimmer adjustment scheme that will help avoid a lot of pruning.

If you check SWR between the ham bands you may find additional resonances where adjacent dipole reactances cancel. For instance, there is a resonance near 27 MHz where the capacitive reactance of the 12-meter dipole resonates with the inductive reactance of the 10-meter dipole. These "false" resonances can be distinguished from the main dipole resonance by their narrow bandwidth. At the frequency of a false resonance, a check with an rf current probe[1] will reveal current on *two adjacent* dipoles; at "*true*" resonance current will be strongly concentrated on only one dipole.

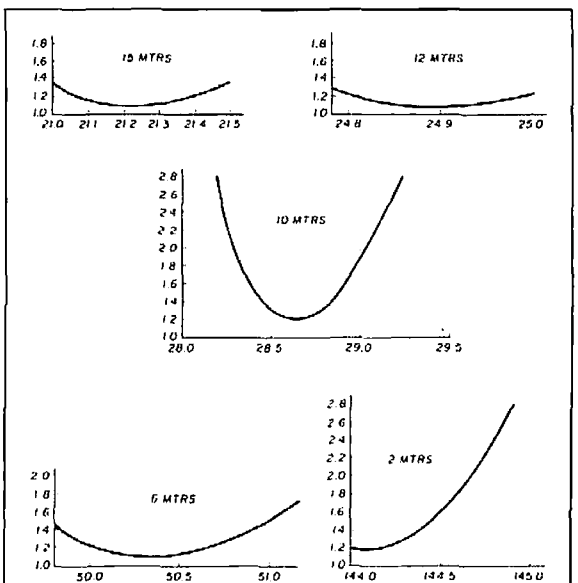


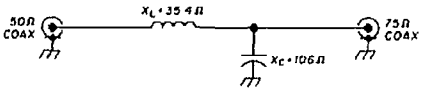
fig. 4. SWR curves measured on 75-ohm coax. The antenna was matched at the low end of 6 and 2 meters where all operating for this particular station is done.

The antenna impedance is close to 70 ohms — a good match to 75-ohm coax and not a bad one to 50-ohm coax. The latter will have a minimum SWR of 1.4 at resonance on each band. Perfectionists can obtain a better match to 50 ohms with a simple L section as shown in **fig. 5**. These L sections are extremely broad band, so no tuning is necessary once you have chosen the correct inductance and capacitance values.

In fact, the 12-meter L section is so broad it will provide a good match over the 15 and 10-meter bands as well. Determine inductance values with a grid-dip meter by shorting the input port, leaving the 75-ohm port open. Target resonant frequencies are given in the table on **fig. 5** along with the L and C values.

results

My antenna is fed through about 100 feet of low-loss 75-ohm 1/2 inch hard line. (I used a cable TV discard.) My results have been impressive on all bands. Sometimes I've worked stations that can't even be heard on a lower antenna. The broad azimuthal coverage provided by four main lobes on 2 meters is often a decided advantage over a beam in working multistation round tables.



BAND (METERS)	L	C	RESONANT FREQUENCY
10,12,15	0.21μH	56pF	46.4 MHz
6	0.112μH	30pF	86.6MHz
2	0.039μH	10pF	255MHz

fig. 5. This simple L-section will provide a broad-band match between 50 and 75 ohm coax. Target values for the inductive and capacitive reactances are 35.4 ohms and 106 ohms, respectively, but values are not critical. The bandwidth is so broad that the 15, 12, and 10 meter bands can be covered with one fixed L-section. If the 50-ohm port is shorted the inductance can be adjusted with a grid dip meter to the frequencies shown in the table.

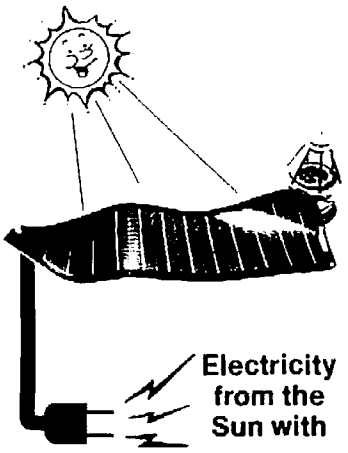
In a pinch, the five-band dipole can even be used on 20 meters in conjunction with an antenna tuner in the shack. The SWR measured a surprisingly low 7:1 on 20, a figure that might be higher if a 1:1 balun had been used at the feedpoint. In any event, a 7:1 SWR will not increase coax losses prohibitively. For instance, if line loss is 1 dB with flat line it will increase only another 1.75 dB when the SWR is 7, or 2.75 dB total. Of course, an SWR of 7 will require an antenna tuner in the shack to bring the impedance back to 50 or 75 ohms resistive. Judging by on-the-air reports, performance on 20 is not bad at all. Maybe it should be called a six-band dipole.

references

1. F. Brown, W6HPH, "Better Results with Indoor Antennas," *QST*, October 1979, page 21, Figure 5.
2. "A Dielectric No-no," Hints and Kinks, *QST*, April 1977, page 56.

Article K ham radio

LET THE SUN DO THE WORK



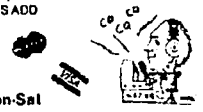
- Charge batteries on stored machinery
- Light your tent
- Run fans
- Run remote transmitters
- Light signs
- Pump water for your animals
- Power for your motor home
- Run your radio without batteries
- Light your home
- Yard lights
- Charge flashlight batteries
- Light your cabin
- Run electric fences
- Charge your boat battery
- Run appliances in your home
- Charge hand held radio batteries
- Fish shanty lights
- Charge your Camcorder battery pack

Electricity from the Sun with

SOLONICS™ SolarSystems

ALSO: *OUTSTANDING* PRICES ON IBM XT COMPATIBLE SYSTEMS!

SHIPPING INFORMATION: PLEASE INCLUDE 10% OF ORDER FOR SHIPPING AND HANDLING CHARGES (MINIMUM $2.50, MAXIMUM $10). CANADIAN ORDERS, ADD $7.50 IN US FUNDS. MICHIGAN RESIDENTS ADD 4% SALES TAX. FOR *FREE* FLYER, SEND 22¢ STAMP OR SASE.



HAL-TRONIX, INC. (313) 281-7773
Hours
12:00 - 6:00 EST Mon-Sat
12671 Dix-Toledo Hwy
P.O. Box 1101
Southgate, MI 48195
✓ 174
"HAL" HAROLD C. NOWLAND W8ZXH

Make the most of your general coverage transceiver with *Monitoring Times*!

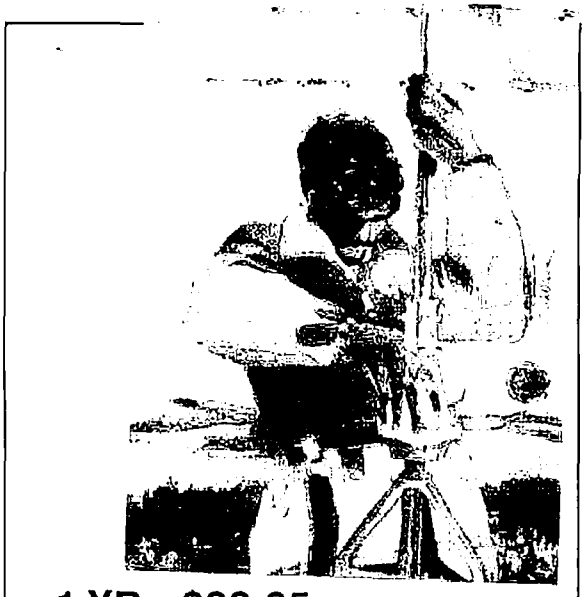
Every month Monitoring Times brings everything you need to make the most of your general coverage transceiver: the latest information on international broadcasting schedules, frequency listings, international DX reports, propagation charts, and tips on how to hear the rare stations. Monitoring Times also keeps you up to date on government, military, police and fire networks, as well as tips on monitoring everything from air-to-ground and ship-to-shore signals to radioteletype, facsimile and space communications.

ORDER YOUR SUBSCRIPTION TODAY before another issue goes by. In the U.S., 1 year, $18; foreign and Canada, 1 year, $26. For a sample issue, send $2 (foreign, send 5 IRCs). For MC/VISA orders ($15 minimum), call 1-704-837-9200.

MONITORING TIMES
Your authoritative source, every month.
P.O. Box 98 A
Brasstown, N.C. 28902

✓ 175

SUBSCRIBE
AND RENEW
TOLL-FREE
HAM RADIO



1 YR - $22.95

2YRS - $38.95

3 YRS - $49.95

Prices U.S. only

MasterCard ☐ MASTERCARD VISA

☐ VISA ☐ BILL ME

Please have your charge card ready.

DATATEL 800™

800-341-1522

Weekdays 8 AM - 9 PM EST

Saturdays 9 AM - 5 PM EST

IN MAINE CALL COLLECT (207) 236-2896

OUR 800 NUMBER IS FOR SUBSCRIPTION ORDERS ONLY!

For Errors or Change of Address
CALL *ham radio* direct at
(603) 878-1441 8-5 EST

RADIOTELEGRAPH CODES:

THERE'S NOT JUST ONE

W. Clem Small, KR6A, R1, Box 64A, Middlebury, Vermont 05769

When radio was young, it was a time of experimentation and growth such as the technical world had never seen. Researchers like DeForest, Marconi, Lodge, and Popov, to name a few, were sharing their findings with an expectant and excited world. It was not clear how best to operate these new radio systems, and various persons and organizations became involved in developing the necessary techniques and procedures.

American Morse code and variations

When it came to the use of coded signals on the airwaves, it might seem that the Morse code was the only way to go. The code had been developed for the land-line telegraph invented by Morse and was in common use in the United States. But, in fact, American Morse code was not even the popular code of the day; **fig. 1** shows the other codes in use.

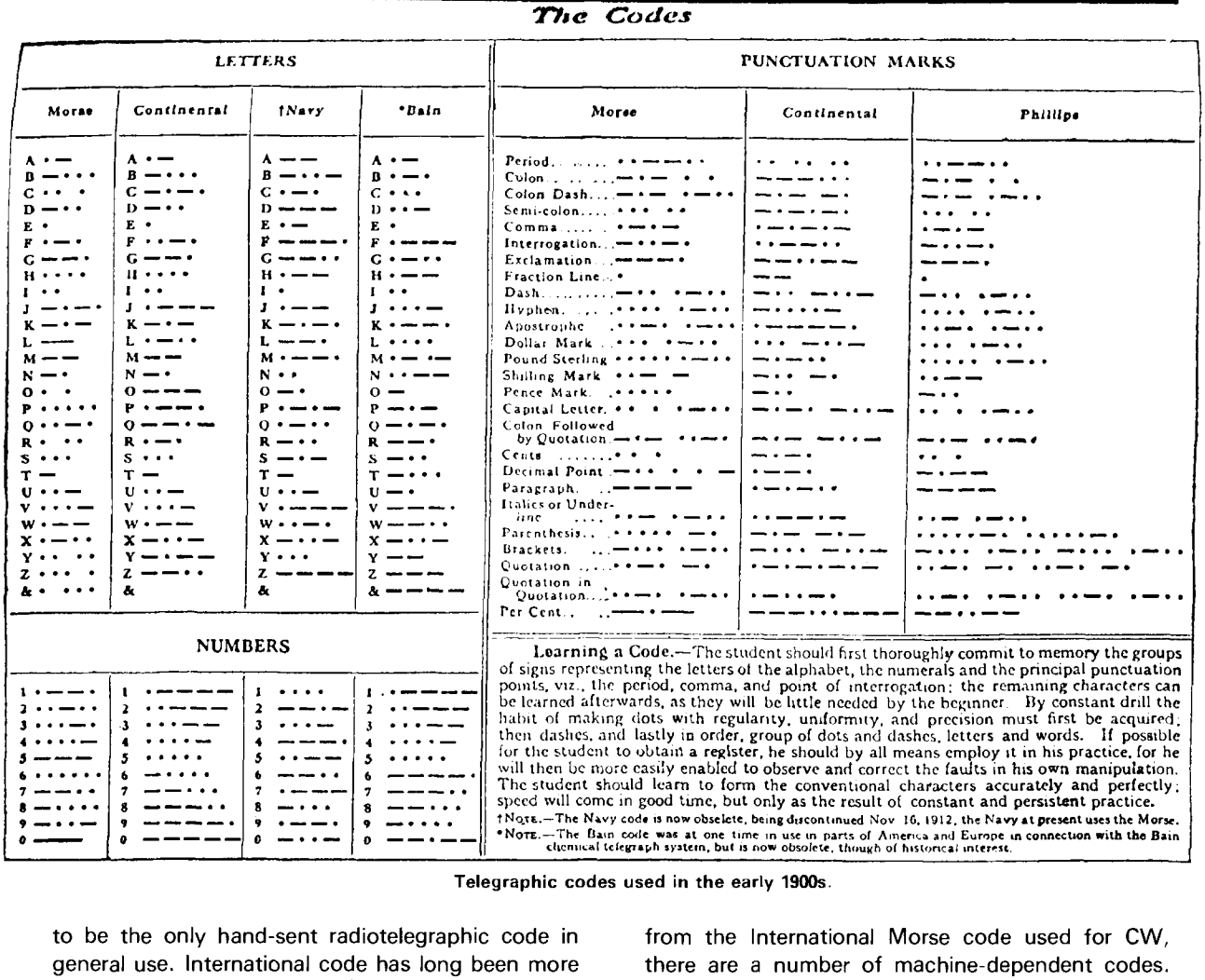
The information in the figure is from *Audel's Handy Book of Practical Electricity*, copyrighted in 1924.[1] As you can see, there were at least five different telegraphic codes being used publicly in the United States back in the early 1900s: Morse, Continental, Navy, Bain, and Phillips. The first four are alphabetic codes, while Phillips provides punctuation. Although much radio communication can be carried on with a minimum of punctuation, the Phillips code was important in radio services reporting newspaper stories. Notes at the bottom of **fig. 1** indicate that the Navy and the Bain codes were already obsolete when Audel's book was published.

international code: the winner

The American Morse code referred to above was Samuel Morse's original code. It seems it was called the "American" version because it was developed and used in the United States. In contrast, the Continental Morse code was used "on the Continent," or in-and-around Europe. You can see from **fig. 1** that these two codes have both similarities and differences.

You may hear old-timers refer to the Continental Morse code as the "general service code."[2] Today, it is known as "International Morse code," and seems

FIGURE 1



The Codes

LETTERS

Morse	Continental	†Navy	*Bain
A • —	A • —	A — —	A • —
B — • • •	B — • • •	B — • • •	B • — •
C — • — •	C — • — •	C — • — •	C • • •
D — • •	D — • •	D — — •	D • • —
E •	E •	E •	E •
F • • — •	F • • — •	F • • — •	F • — — —
G — — •	G — — •	G — — •	G • — • •
H • • • •	H • • • •	H • • • •	H • — —
I • •	I • •	I •	I • •
J • — — —	J • — — —	J • — —	J • • • —
K — • —	K — • —	K — • — •	K • — — •
L • — • •	L • — • •	L — — •	L • • •
M — —	M — —	M • — — •	M • — • —
N — •	N — •	N — •	N • • — —
O — — —	O — — —	O — •	O —
P • — — •	P • — — •	P • — • —	P — • —
Q — — • —	Q — — • —	Q • — — •	Q — • — •
R • — •	R • — •	R — • •	R — — •
S • • •	S • • •	S — • —	S — • •
T —	T —	T —	T — • • •
U • • —	U • • —	U • • —	U — •
V • • • —	V • • • —	V • — — —	V — — — •
W • — —	W • — —	W • — —	W — — • •
X — • • —	X — • • —	X — • • —	X — • • —
Y — • — —	Y — • — —	Y • • •	Y — —
Z — — • •	Z — — • •	Z — — — —	Z — — —
& • • •	&	&	& — — — —

NUMBERS

1 • — — — —	1 • — — — —	1 • • • •	1 • — — — —
2 • • — — —	2 • • — — —	2 — — • —	2 • • — — —
3 • • • — —	3 • • • — —	3 • • • —	3 • • • — —
4 • • • • —	4 • • • • —	4 — — — •	4 • • • • —
5 — — — —	5 • • • • •	5 • • — —	5 • • • • •
6 — • • • •	6 — • • • •	6 — — • •	6 — — — — •
7 — — — • •	7 — — — • •	7 • — — —	7 — — — • •
8 — — • • •	8 — — — — • •	8 — • • •	8 — — • • •
9 — — • • —	9 — — — — — •	9 • — — •	9 — — • • •
0 — — — — —	0 — — — — —	0 — • • —	0 — — • — —

PUNCTUATION MARKS

Morse	Continental	Phillips
Period • • — — • —	• — • — • —	• — — — • —
Colon — — — • • •	— — — • • •	— — • — • •
Colon Dash — • — • — •	— • — — • —	— • — • — — •
Semi-colon — • — • — •	— • — • — •	— • — • •
Comma • — — • — —	• — — • — —	• — — • —
Interrogation • • — — • •	• • — — • •	— • • — •
Exclamation — — — • —	— — • — —	— — — •
Fraction Line — •	— —	•
Dash — • • —	— • • —	— • • — •
Hyphen — • • • • —	— • • • • —	— • • — •
Apostrophe • — — — — •	• — — — — •	• — — — • — — •
Dollar Mark • • • — • • —	• • • — • • —	• • • — • — •
Pound Sterling • — • — • •	— • — • •	• — • — • — •
Shilling Mark • — • —	— • — •	• — —
Pence Mark • — • — •	— • — •	— •
Capital Letter • • — • — • —	— • — • — • —	• • — • — • —
Colon Followed by Quotation — • — — • — •	— • — — • — •	— • — — • — •
Cents — • — •	— • — •	• • — •
Decimal Point — • — • — •	• — — •	— • — —
Paragraph • — • — • •	• — • — • •	— — — —
Italics or Underline • • — — • —	• • — — • —	• • — — • —
Parenthesis — • — — • —	— • — — • —	• • • • • — • • • • • — •
Brackets — — • • • — — •	— • • • — — •	— — • • • — — • • • — — • • • — •
Quotation • • — — • — •	• — • — • — •	• • — • • — • • • — • — •
Quotation in Quotation • • — — • — — •	• — • • — •	• • — • • — • • • — • — • •
Per Cent — — — • • — — —	— — — • • — — —	— — • • — —

Learning a Code.—The student should first thoroughly commit to memory the groups of signs representing the letters of the alphabet, the numerals and the principal punctuation points, viz., the period, comma, and point of interrogation; the remaining characters can be learned afterwards, as they will be little needed by the beginner. By constant drill the habit of making dots with regularity, uniformity, and precision must first be acquired; then dashes, and lastly in order, group of dots and dashes, letters and words. If possible for the student to obtain a register, he should by all means employ it in his practice, for he will then be more easily enabled to observe and correct the faults in his own manipulation. The student should learn to form the conventional characters accurately and perfectly; speed will come in good time, but only as the result of constant and persistent practice.

†NOTE.—The Navy code is now obsolete, being discontinued Nov 16, 1912, the Navy at present uses the Morse.

*NOTE.—The Bain code was at one time in use in parts of America and Europe in connection with the Bain chemical telegraph system, but is now obsolete, though of historical interest.

Telegraphic codes used in the early 1900s.

to be the only hand-sent radiotelegraphic code in general use. International code has long been more popular than American, even though American Morse code was said to be about five percent faster because it has fewer dashes.[3] Graf indicates that American Morse code was used, to a limited extent, at least as late as 1962 on land telegraph lines in this country.[4]

The secret of the International code's success over American may lie in this quotation from the 1924 edition of the International Correspondence School's *Radio Operator's Handbook*: "The International Morse code is used all over the world for radio and submarine telegraphy, and for wire telegraphy in almost every country except the United States, Canada, and parts of Australia. It is superior for signaling through long submarine cables, as some of the recording devices used in that work do not give accurate signals when used with spaced letters."[5]

Although it may appear that International Morse code is the only telegraphic code we have ever had, history tells us otherwise. There is still a proliferation of radiotelegraphic *type* codes today. Aside from the International Morse code used for CW, there are a number of machine-dependent codes. These are: RTTY Baudot code, and the variants used with SITOR, AMTOR, and packet. There's also the ASCII computer code used in machine-dependent radiotelegraphy.

While the use of hand-sent code is not as prevalent as in the past, radiotelegraphic *type* codes are far from becoming an endangered species. Indeed, communications on the air waves, and even over telephone lines, would be seriously diminished without them!

references

1. Frank D. Graham, *Audel's Handy Book of Practical Electricity*, Theo. Audel & Co., New York, 1924, page 831.
2. Rufus P. Turner, *The Illustrated Dictionary of Electronics*, Tab Books, Blue Ridge Summit, Pennsylvania, 1980, page 167.
3. Sidney Gernsback, *1927 Radio Encyclopedia*, originally published by Sidney Gernsback in 1927, reprinted in 1974 by Vintage Radio, Palos Verdes Peninsula, California, page 38-39.
4. Rudolph F.Graf, *Modern Dictionary of Electronics*, Howard W. Sams & Co. Inc., Indianapolis, 1962.
5. International Correspondence Schools Staff, *Radio Operator's Handbook*, The John C. Winston Co., Chicago, 1924, page 406.

Article L

Low-cost
direct frequency display
for any receiver

add a digital readout to the "poor man's spectrum analyzer"

An article in the September 1986 issue of *ham radio*, "Low-cost Spectrum Analyzer with Kilobuck Features" by W4UCH, illustrated the use of a voltage-tuned (varactor) TV tuner as a swept, tuned filter. I wanted to add a circuit that would directly read out the center frequency of the CRT display.

The unusually high i-f frequency (610 MHz) used in the modified cable TV tuner makes this application different from the usual Amateur receiver digital readout. Typical receiver i-f frequencies are relatively low: 455 kHz; and 4, 9, 10.7, and 21.4 MHz. Expansion of activity into the VHF, UHF, and microwave bands is forcing receiver designers to use much higher i-f frequencies to reduce image problems.

My solution is an inexpensive circuit combining both digital and analog circuitry, which simplifies the task of accommodating a wide range of i-f offset frequencies. While the circuit was developed specifically for the "Poor Man's Spectrum Analyzer", it can be used for any other type of receiver. A simple potentiometer adjustment is all that is needed to accommodate any i-f frequency from zero to hundreds of MHz.

previous approaches to the problem

Most frequency readout circuits use the local oscillator signal to generate the display. Because this signal is offset from the incoming rf signal by an amount equal to the i-f frequency, some arithmetic must be performed to either add or subtract the i-f from the LO signal to get back to the received frequency. The biggest problem with other "universal" frequency displays has been the circuitry required to offset the display of the receiver's local oscillator frequency by the i-f frequency. Heterodyne oscillators or presetting counters had to be used to add or subtract the i-f, or games had to be played with the timebase to accomplish the same result. None of these methods provided a very satisfactory solution.

the numbers involved

The varactor tuner used in the spectrum analyzer is a cable tuner modified to tune from 0 to 500 MHz as the tuning voltage is varied from 0 to 24 volts. The incoming signal is upconverted to 610 MHz in the tuner by mixing it with a voltage-controlled oscillator (VCO), which is varied from 610 MHz to 1110 MHz. This VCO signal is also fed to a prescaler in the tuner which divides it by 256. The output of the prescaler is a signal that swings from 2.38 MHz (610 divided by 256) to 4.34 MHz (1110 divided by 256) as the tuner tunes from 0 to 500 MHz. This signal is brought out to a terminal on the side of the tuner and is the signal that I had to work with to create my direct digital frequency display.

To analyze how the circuit works, I stopped the sweep, picked a single input frequency, and followed it through to the display (see **fig. 1**). I tuned to 100 MHz. Because the tuner upconverts to 610 MHz, the VCO must operate at 610 MHz above or below 100 MHz. In this tuner it operates above the incoming signal, so it is oscillating at 710 MHz. The prescaler divides this 710 MHz signal by 256, producing an output of 2.77 MHz. Now the 2.77 MHz number must be converted to display 100 on the digital readout.

Multiplying this 2.77 number by 256 reverses the action of the divide-by-256 prescaler and returns it to the local oscillator frequency. A conventional counter could then be used to display this frequency, but the

By Murray Barlowe, WA2PZO, P.O. Box 310, Bethpage, New York 11714

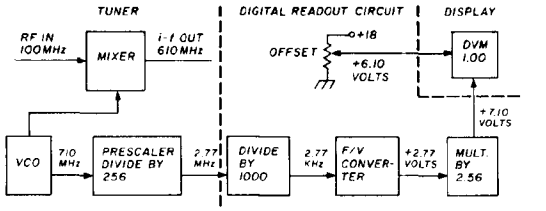


fig. 1. System block diagram.

resulting display would always be 610 MHz higher than the actual frequency. I would then have to subtract 610 from the number displayed to determine the actual center frequency or build an offset counter with dip switches to preset the i-f frequency offset. I didn't care for either of these methods. The first was too inconvenient, and the second was too expensive and limited.

I wondered how the new state-of-the-art receivers display the received frequency. A little investigation revealed that they were all synthesized and used microprocessors to provide the data for the display.

must the solution be "digital only"?

A friend, KA2TCH, mentioned that some voltage-to-frequency converter chips could also be run as frequency-to-voltage converters. Looking through the data books, I found a Precision V/F converter chip (LM-331) that would also work as an F/V converter. However, the data sheet disclosed that 10 kHz was the highest input frequency it could accept. I figured I could do something about that. Breadboarding the circuit proved that it really worked as advertised. A plot of the input frequency versus the output voltage illustrated its excellent linearity. The result was a simple, precise one-chip frequency-to-voltage converter.

Since the output of the prescaler as it is tuned from 0 to 500 MHz is approximately 2 to 4 MHz, dividing it by 1,000 brings it down to 2 to 4 kHz. This fits well into the input frequency range of the F/V converter. I chose to use a pair of dual decade divider chips (74LS390) to perform this function. Each chip contains two divide-by-2 and two divide-by-5 circuits. Cascading all the circuits in each chip provides a divide-by-100 result. As division by 1,000 was required, the first chip was connected to divide by 100, and only half of the second chip was used to divide by 10. These two chips were added in front of the F/V converter, and sure enough, the 2 to 4 MHz input from the prescaler produced 2 to 4 volts dc out of the F/V converter.

more breakthroughs

At this point, I could use a digital voltmeter as a digital frequency display. This saves the cost and inconvenience of building a LED or LCD decoder, driver, and display circuit. It also has the added advantage of eliminating a serious source of RFI generated by more TTL and multiplexing circuitry that could be picked up by the spectrum analyzer.

recap

The four steps taken so far in the F/V conversion scheme are:

- The incoming 100-MHz signal is upconverted to 610 MHz. This means that the VCO is operating at 710 MHz (rf + i-f = OSC).
- The prescaler divides this 710-MHz signal by 256, producing a 2.77-MHz signal.
- The two counter chips divide this 2.77-MHz signal by 1,000, providing a 2.77-kHz signal for the F/V converter chip.
- The F/V converter chip converts the 2.77-kHz signal to 2.77 volts.

the second half of the process

So far the incoming 100-MHz signal has been converted to 2.77 volts. Now it's time to reverse the process, return to 100 MHz, and display the result.

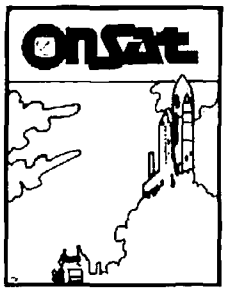
First, interpret the 2.77-volt reading displayed on the meter as 2.77 MHz — a mental conversion which accomplishes two steps. I performed a voltage-to-frequency conversion (2.77 volts = 2.77 MHz) and then reversed the action of the divide-by-1,000 part of the circuit by accepting the concept that the number 2.77 was in MHz, rather than in kHz (2.77 kHz × 1,000 = 2.77 MHz). This reversed the action of the third and fourth steps in the previous F/V conversion process, bringing us to the second step — the divide-by-256 prescaler.

Now 2.77 volts (representing 2.77 MHz) must be multiplied by a number which will result in 710, the frequency of the VCO in MHz. Since the prescaler divided 710 by 256 to get 2.77, multiplying 2.77 by 256 comes back to 710. This presents a bit of a problem. We are dealing with dc voltages and so 710 volts requires high-voltage power supplies and other high-voltage components. Another mental conversion is needed so that a voltmeter display of 7.10 volts represents 710 MHz. Now the process can be continued with practical voltage levels. Multiply 2.77 volts by 2.56 to get 7.10 volts. A simple direct coupled op-amp with a gain of 2.56 does the job. All that remains is to subtract 610 from 710 to get the original 100-MHz rf input signal.

Since the level of the numbers has been scaled down by a factor of 100, subtract 6.10 volts from 7.10 volts to get 1.00 volt to represent 100 MHz. This 610 represents the i-f offset frequency, which has always been a major problem when designing a universal di-

OnSat

"America's Weekly Guide to Satellite TV"



The best in satellite programming! Featuring: ★ Over 120 Channels listed ★ Weekly, Updated Listings ★ Magazine Format ★ Complete Alphabetical Movie Listings ★ Sports Specials ★ Prime Time Grids ★ Specials ★Programming Updates!

- **Only $45.00 per year (52 weekly issues)**
- **2 Years $79.00 (104 weekly issues)**
- **$1.00 for sample copy**

*NC Residents must add 5% Sales Tax

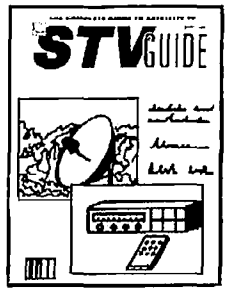
Subscribe Today!

call toll free 1-800-234-0021
Visa® and MasterCard® accepted

OnSat PO Box 2347 Shelby, NC 28151-2347

STV GUIDE

The new **STV Guide** contains valuable information on zoning regulations, scrambling, plus technical tips for installing or updating a satellite system—and now a precise monthly guide to satellite TV with the latest program listings for over **90 channels**!



All this in each complete issue of **STV Guide**!

- **Only $48.00 per year (12 monthly issues)**
- **$2.00 for a sample copy**

*NC Residents must add 5% sales tax

Subscribe Today!

Call toll free 1-800-234-0021
Visa® and MasterCard® accepted

STV Guide PO Box 2384 Shelby, NC 28151-2384

rect digital frequency display. The solution to this last problem is one some of us old-timers, who played with analog computers long before the advent of their digital counterparts, will like. To have a voltmeter read 1.00 volt when the positive terminal is connected to 7.10 volts requires only that the negative terminal of the meter be connected to + 6.10 volts. The difference of 1.00 volt now appears across the meter terminals.

Returning the negative terminal of the meter to the center arm of a potentiometer connected across the supply and labeling the control "offset" creates a universal direct digital frequency display (see schematic). A simple adjustment of a potentiometer allows offsetting (subtracting) of any i-f frequency and display of the rf frequency tuned by the receiver. Who said analog computers were obsolete?

display options

I designed this circuit (shown in **fig. 2**) so that it could use your digital voltmeter as the frequency display. With the meter set on the 20-volt dc scale, 0 to 500 MHz would be displayed as 0.00 to 5.00 volts. I found the decimal point annoying at first, but was soon able to ignore it. Later, I bought a $29 digital voltmeter (DVM), disabled the decimal point, and used it in my spectrum analyzer application. Now the display reads out directly in MHz. Miniature DVMs that are ideal for this application are available from Acculex. They measure 1 x 2 x 0.5 inches and mount easily into a rectangular cutout.

For those who would rather use a regular digital frequency counter instead of a digital voltmeter to display the result, a second F/V chip connected as a voltage-to-frequency converter would do the trick. The voltage that was intended for the DVM would now be converted to a frequency that could be read by the counter. However, the 1.00 volt displayed on the DVM and read as 100 MHz would now produce 1.00 kHz on the counter — which would also have to be interpreted as 100 MHz.

displaying the center frequency while scanning

The tuner used in the spectrum analyzer is voltage tuned so that it can be swept across a wide range of frequencies with a sawtooth voltage waveform. This action makes the tuner function as a voltage-tuned filter, which is a key element of a spectrum analyzer. As the tuner sweeps across the band, all signals received are amplified and rectified, and the resulting voltage is applied to the vertical input of a scope. The horizontal sweep of the scope is synchronized with the sawtooth used to cause the tuner to scan, so that the scope display shows a series of vertical "pips", each one representing a received signal. The vertical am-

190

plitude of the pip is proportional to the strength of the signal, while its location on the horizontal axis represents its frequency.

To simplify the analysis of how the circuit works, I put aside the fact that the local oscillator in the spectrum analyzer was being swept above and below the center frequency by the 20-Hz sawtooth. (This is not a problem for those who would use this circuit in a more conventional receiver.)

The VCO in the spectrum analyzer is constantly changing frequency. It is being swept several MHz above and below the center frequency, approximately 20 times per second, by the sawtooth scanning voltage. The center frequency of the band of frequencies being scanned must be displayed.

One approach used by commercial spectrum analyzers is to use a comparator to sense when the sawtooth is halfway through its scan, open a gate for a millisecond or so, and sample and display the VCO frequency. Then, a counter that has been preset to add or subtract the i-f frequency (depending on whether the VCO is operating above or below the incoming signal) is used to count and display the center frequency. This would require a complete offset digital counter, along with a stable timebase, plus the necessary gating circuits.

My original plan was to add a circuit that would dectect the center of the sawtooth sweep waveform, as in commercial analyzers, and use a sample and hold circuit to save the value of the dc produced by the F/V converter. However, after completing the circuit and using the tuner without the sweep, I realized that this additional circuitry might be unnecessary. The frequency-to-voltage converter uses an RC time constant across which it develops the dc output voltage. I reasoned that if the sawtooth sweep were symmetrical about the center frequency, it would produce a 20-Hz ac component riding on the dc component that represented the center frequency. The average dc voltage would not be changed. In addition, the time constant (1 μF × 100k) might be large enough to absorb this small ac component. Applying the sawtooth sweep to the tuner proved that my reasoning was correct. The display remains constant unless the sweep width is increased to hundreds of MHz, when it might become unsymmetrical.

constructing the circuit

To simplify construction, the art work for the double-sided pc board is shown in **figs. 3** and **4**. I found it necessary to use a double-sided board with maximum groundplane on both sides to eliminate RFI generated by the two digital chips. Construction is straightforward. All the components are mounted on one side of the board.

A number of test points have been provided for test-

COMPUTERIZE YOUR SHACK

YAESU 747, 757GX, 757GXII, 767, 9600.
KENWOOD TS 140, 440, 940, 660, R5000.
ICOM R71A, H7000, 735, 751A, 761, 781, AND ALL VHF, UHF, CI-V.
DRIVERS FOR RADIOS ARE MODULAR.
JRC NRD 525.

COMPLETE PROGRAM ENVIRONMENT.
MENU DRIVEN AND DESIGNED FOR EASE OF USE.
SCAN FUNCTION ADDED TO RADIOS THAT DO NOT SUPPORT IT.
ERGONOMETRICALLY DESIGNED FOR EASE OF OPERATION.
MOST FUNCTIONS REQUIRE SINGLE KEYSTROKES.
PROGRAM COLOR CODED FOR EASE OF USE, ALTHOUGH WILL STILL RUN IN A MONOCHROME SYSTEM.

MENUS FOR THE FOLLOWING:
AMATEUR HF—AMATEUR VHF— AMATEUR UHF
AM BROADCAST—FM BROADCAST—TELEVISION BROADCAST
SHORT WAVE BROADCAST
AVIATION HF(SSB)—AVIATION VHF—AVIATION UHF
HIGH SEAS MARINE—VHF MARINE
MISCELLANEOUS HF, VHF, UHF
MOST POPULAR FREQUENCIES ALREADY STORED
ADDITIONAL LIBRARIES AVAILABLE
COMPLETE LOGGING FACILITY
ALL FREQUENCY FILES MAY BE ADDED TO, EDITED OR DELETED

AVAILABLE FOR IBM PC, XT, AT, 80386 256K RAM
1 SERIAL PORT AND 1 FLOPPY MINIMUM

PROGRAM WITH INITIAL LIBRARIES	**99.95**
RS-232 TO TTL INTERFACE ONLY (NEEDED IF DON'T HAVE MANUFACTURERS INTERFACE)	
EXTERNAL INTERFACE ALLOWS 4 RADIOS	**99.95**
INTERNAL PC INTERFACE W/1 SERIAL & 1 RADIO PORT	**129.95**
SPECTRUM ANALYZER MODULE	(CALL FOR PRICE)
COMPLETE SYSTEMS INCL. RADIO, INTERFACE, COMPUTER, AVAILABLE	(CALL FOR PRICE)

DATACOM, INT.
8081 W. 21ST LANE
HIALEAH, FL 33016
AREA CODE (305) 822-6028

✓ 176

KEEP IT INSIDE



- **Frequency Range** - 13 MHz to 30 MHz
- **Power Limit** - 1500 Watts P.E.P
- **Diameter** - 39 inches
- **Wind Survival** - 70 + MPH
- **Surface Area** - < .89 Sq. Ft
- **Antenna Finish** - Heat Shrink Tubing
- **Coax Connector** - PL-259
- **Antenna Weight** - 4 lbs.
- Magnetic Design Maximum Efficiency
- 100% Copper One Piece Construction
- *Military Spec Vacuum Variable* Capacitor Rated at 35,000 Volts
- Hi-Q Harmonic Supression
- All Locations - Indoors or Outdoors
- Bi-Directional at 0-20 Degrees TOA
- Omni-Directional at 25-90 Degrees TOA
- High Signal to Noise Ratio
- Direct Feed 52 OHM Coax SWR < 1.5:1
- No Matching Unit, Pretuned Coax, Ground Screen or Radial System

WA2VMO A BELIEVER

WHEN YOU'RE TOLD YOU CAN'T — THE DMD-5588 SAYS YOU CAN

OPERATION: Apply power to DMD-5588 and adjust vacuum variable for lowest SWR

INSTALLATION: DMQ-5588 inside ground floor apartment brick building 100W.

DX CONTACTS MADE BETWEEN 3/88 TO 5/88: 5Z4 P43 PAO TK9 DJ8 GW0 CP5 YS9 ZS6 J37 ZD8 HP9 WP4 IK4 HK6 GM4 I5 EA5 JH1 C6 HK6 IK2 GO4 PJ2 HP4 CE1 5Z4 5T5 KP4 UT4 SP3 CP3 F9 IK3 N91 UA6, UR2 UP1 YT2 UB5 IV3 EA5 TG9 GJ5 ON7 YU1 VO1 DL6 J73 PY8 TI2 LZ1 PY5 OE4 GI0 G4 WP4 KL7

Become a Believer! For more information about this exciting new antenna, call or write DMQ today! Limited time intro offer: $349.50 + Shipping.

221 Slater Boulevard
Staten Island, NY 10305
(718) 979-3505

DMQ TECHNOLOGY

✓ 177

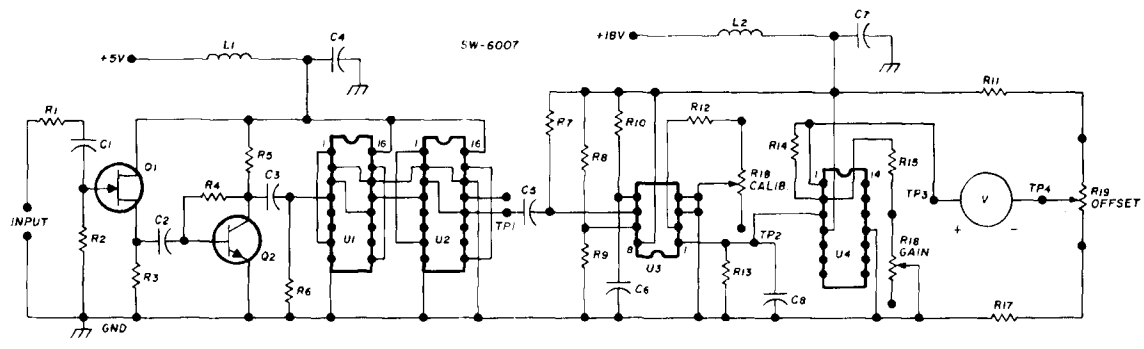


fig. 2. Center frequency digital display.

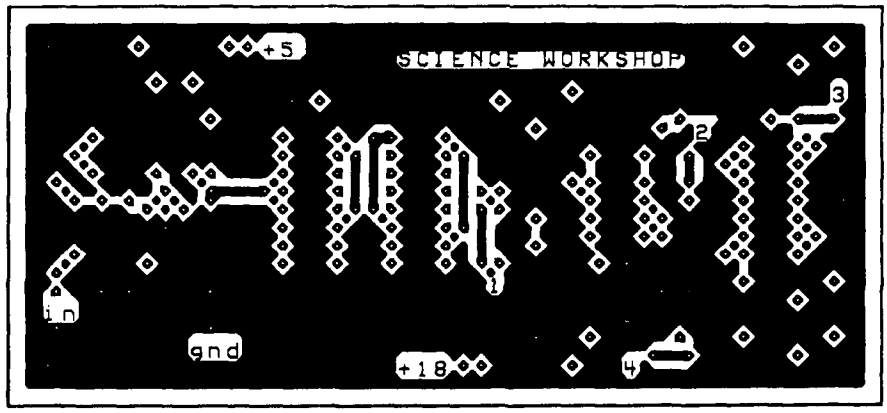


fig. 3. Component side of double-sided pc board.

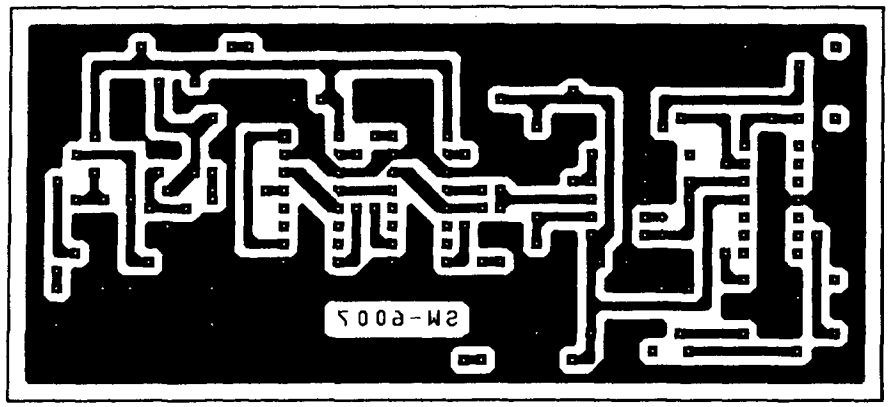


fig. 4. Top side of double-sided pc board.

ing and calibration. The following assembly procedure is recommended:

• Install eight jumpers as indicated in **fig. 5**. The jumpers labeled 1, 2, 3, and 4 will be used as test points for calibration and should be formed as "loops" (see **fig. 5**). Install two inductors, 16 resistors, and three

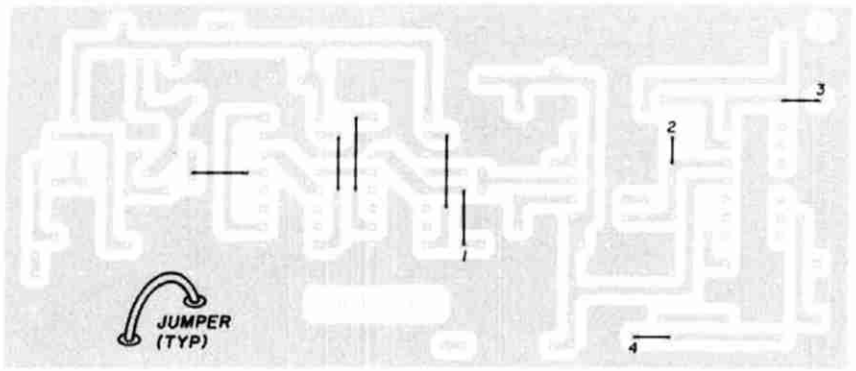


fig. 5. Jumpers numbered 1 through 4 should be formed into "loops" for test points. Numbers 3 and 4 are also used as "output" terminals. See jumper closeup in lower left hand corner.

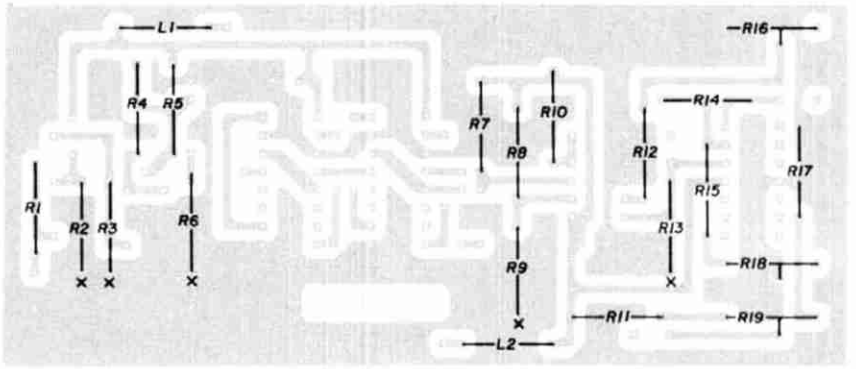


fig. 6. Inductors, resistors and trimpots.

trimpots as indicated in **fig. 6**. Solder the grounded ends of the five resistors marked "x" on both sides of the pc board.

• Install two transistors and eight capacitors as indicated in **fig. 7**. For ease of installation, use sockets for the four chips. Insert them in the locations indicated. (Note the location of the number 1 pin.)

• Check your work carefully for excess solder, splashes, shorts, or "cold" solder joints. This completes the assembly of the frequency readout board.

test and calibration procedure

The accuracy of the display is directly related to the stability of the supply voltage. Final calibration should not be performed until the power supply has warmed up and is stable. Since the circuits work with small dc voltages, paying careful attention to setup measurements will assure accurate results. Proceed as follows:

• Connect a digital voltmeter between test point 3 and ground.

• Connect regulated + 18 volts between the + 18 volt terminal and ground. Neither the +5 volt supply nor the input signal needs to be connected at this time.

• Apply +2.77 volts between test point 2 and ground.

• Adjust the gain trimpot (R18) for 7.10 volts at test point 3.

• Shift the digital voltmeter negative test lead from ground to test point 4. Leave the positive test lead at test point 3.

• Adjust the offset trimpot (R19) for 1.00 volt on the DVM.

• Now connect the output of the prescaler of the tuner to the input of the digital readout board. Also con-

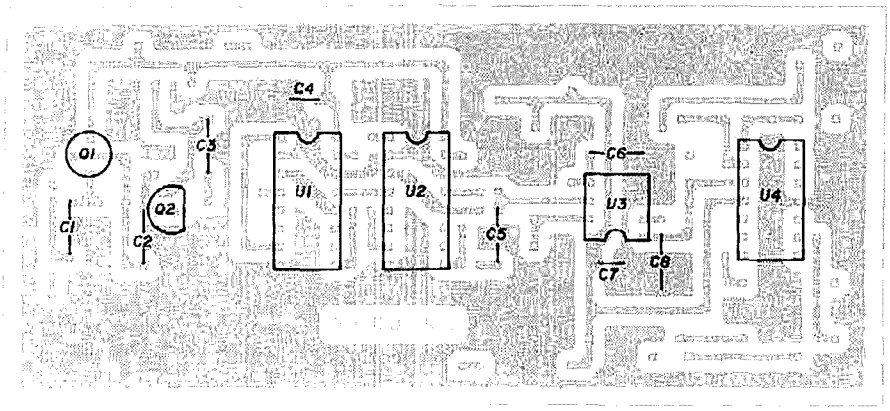


fig. 7. Transistors, capacitors and chips.

Parts list

Capacitors
C1 .02 μF
C2 .02 μF
C3 .02 μF
C4 .1 μF
C5 470 pF
C6 .01 μF
C7 .1 μF
C8 1.0 μF

Inductors
L1 1 mH rf choke
L2 1 mH rf choke

Resistors
R1 2.2k
R2 1 megohm
R3 750 ohm
R4 68k
R5 470 ohm
R6 1k
R7 10k
R8 10k
R9 68k
R10 6.8k
R11 33k
R12 13k
R13 100k
R14 68k
R14 100k
R15 39k
R16 5k*
R17 20k
R18 10k*
R19 5k*
* = trimpots

Transistors
Q1 S31801
Q2 5972

nect the +5 volt regulated supply between the +5 volt terminal and ground.

- If a signal generator is available, set it to 100 MHz and tune the spectrum analyzer so that the 100-MHz signal is centered on the CRT. Use a relatively small scan width setting on the analyzer. (If a signal generator is not available, any known signal can be used.)
- Adjust the calibration trimpot (R16) for 1.00 volt (representing 100 MHz) on the DVM. This completes the calibration process.

troubleshooting

Your scope and DVM are all you need to find a problem if the calibration procedure can't be performed. The first part of the calibration procedure uses the circuits of the op-amp, U4. Any problem here would be limited to this chip and its components.

The second part of the procedure depends upon the correct operation of the remainder of the circuit. It can be broken down into three parts — the preamp, the dividers, and the F/V converter. Use your scope to check the operation of the preamp (Q1 and Q2) and the dividers (U1 and U2). Trace the 2.38 to 4.34-MHz signal from the tuner presecaler output to the board and through the preamp. Remember, +5 volts must be supplied to the prescaler +5 terminal on the tuner. The jumper between the output of the preamp and pin 4 of U1 is a convenient place to check for the preamp output. It should be approximately 3 volts peak to peak. No signal would indicate a problem in the preamp.

Next check test point 1. You should find a square-wave of almost 5 volts peak to peak. No signal would indicate a problem in the divider circuits.

Finally, your DVM connected to test point 2 should show a dc voltage that will vary from 2.38 volts to 4.34 volts, depending on the frequency tuned by the varactor tuner.

The divider circuits on this board may generate spurious signals that can get into the tuner and show up on the CRT display. Check this by disconnecting the input signal to the board. Using a double-sided board with maximum groundplane area, in conjunction with L1 and L2, should prevent this. If it persists, check the grounding between the groundplanes of the pc board and the chassis. It may be necessary to add additional capacitive filtering to the +5 and +18 volt leads at the board terminals. This means both high-frequency (feedthrough) capacitors and electrolytic

capacitors; otherwise, the power supply leads may radiate.

other applications

This direct frequency readout circuit can be used with any i-f. All you need to do is feed the local oscillator signal into the input of the board, making sure that the output frequency of the dividers falls within the range (approximately 0.5-10 kHz) of the F/V converter, and performing the calibration procedure. Adding a divide-by-256 prescaler (as in the cable tuner) ahead of the pre-amp input on the board allows use of local oscillator inputs over 1 GHz.

Changing some of the jumpers (note the extra hole above the jumper at test point 1) provides extra flexibility. You can choose the output of the dividers so that the input is divided by any combination of the four divide-by-2 and divide-by-5 stages. The input and output of the individual divider stages can be brought out to a front panel switch to provide a wide range of frequencies that can be measured by this circuit. I'd be interested in hearing any ideas you might have for using this circuit.

A complete kit of parts is available from the author.

Article M **ham radio**

INTERNATIONAL MONTHLY MAGAZINE BY AND FOR ACTIVE RADIOAMATEURS

Radiosporting

THIS IS IT! - FOR BIG GUNS & LITTLE PISTOLS

A magazine dedicated to quality and sportsmanship in amateur radio operating. Fresh, timely, practical and down to earth reading for little pistols and big guns. Written by the world's best in their fields: ON4UN, SMØAGD, LZ2CJ, VE3BMV, KH6BZF, DJ9ZB, ZS6BRZ, W1WY, N2SS, K7GCO, K4ZN, W4GF, VE3JTQ, WB4ZNH, WB9TBU, KQ2M, NS6X, W2XQ, W3FG, KA3B, K1PLR, N3IK, N7CKD, VE3XN, ABØX, JE1CKA and others.

Includes DX News, QSL Info, 160m, 80m, 10m, 6m columns, DXpeditioning, Propagation, Awards, Contest Rules and Results, Traffic - Emergency, FCC News, New Products, Antennas, Technical News and articles, Equipment Reviews and Modifications, Computer Programs, Radio Funnies, Club Life, SWL, RTTY, VHF/UHF, Mail Box, Classified Ads and much more in a magazine format with the speed of a bulletin. RADIOSPORTING sponsors DX Centurion Award, Contest Hall of Fame and World Radio Championship contest.

"Your publication is superb! Keep it up!" Joe Reisert, W1JR

"Your W2PV articles are priceless. Your magazine is super!" Rush Drake, W7RM

"Let me congratulate you on a very impressive magazine. Just what I've been looking for as a DXer and Contester!" Dick Moen, N7RO

"RADIOSPORTING, once received, cannot be tossed aside until it is read from cover to cover. Then reviewed again and again." Chas Browning, W4PKA

"I take every ham magazine and can say without reservation that *RADIOSPORTING is the first one read each month.*" Joe Rudi, NK7U, "Oakland A's"

Subscription rates: 1 year USA $18, Canada CDN$28, Overseas US$25; 2 years $33, $50, $44 respectively. Single issue $2.

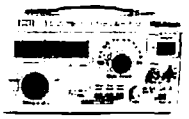
USA First Class Mail add $10/year, DX Air Mail add $20/year.

TRY US! SUBSCRIBE OR SEND $1 FOR YOUR SAMPLE COPY. *VISA, MASTERCARD accepted.*

RADIOSPORTING Magazine ✓ 178
PO Box 282, Pine Brook, NJ 07058, USA Tel. (201) 227-0712

NOVEX

RF Signal Generator/Counter

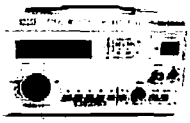


- 1 - 150 MHz
- Harmonics to 450
- AM modulation
- XTAL input/check
- Digital readout

NOVEX SG4162AD only $249.95 + $4 S&H

NOVEX SG4160A same as above except no digital readout/counter only $149.95 + $4 S&H

AF Audio Generator/Counter



- 10 Hz - 1 MHz
- Sine - sq wave
- Low distortion
- 8V RMS output
- Digital readout

NOVEX AG2603AD only $249.95 + $4 S&H

NOVEX AG2601A similar to above except no digital readout, counter only $149.95 + $4 S&H

Function Generator



- Sine, sq, triangle
- .5 Hz - 5 MHz
- DC offset
- 20 Vpp output
- 120 VAC power
- includes test leads

✓ External inputs can control AM (VCA) or FM (VCF) and produce AM, FM, sweep, ASK, or FSK signals

NOVEX FG2020A only $149.95 + 4 S&H

Orders: 800-368-3270 Tech info: 703-opt 2350
EEB Electronic Equipment Bank
3161 Mill St. NE, Vienna, VA 22180
(not a store in Washington DC)

✓ 179

TOWERS by ALUMA HR-2

HIGHEST QUALITY ALUMINUM

T-140 40' Crank-Up Tower

- TELESCOPING (CRANK-UP)
- GUYED (STACK-UP)
- TILT-OVER MODELS

Easy to install. Low Prices. Crank-ups to 100 feet.

EXCELLENT FOR AMATEUR COMMUNICATIONS

Over 36 types aluminum towers made — specials designed and made — Write for details.

T-40H 40' Heavy Duty Ham Tower Crank-Up





SPECIAL Four Section 50 Ft. Van Mounted Crank-up Aluma Tower



ALUMA TOWER CO.
BOX 2806HR
VERO BEACH, FL 32961-2806
(305) 567-3423 803405 MAIN-VERO

✓ 180

RELY ON JAN FOR 3-WAY HELP:

1. TECHNICALLY CORRECT CRYSTALS TO YOUR SPECS.
2. QUICK TURNAROUND WITH HUGE INVENTORY, PROMPT SERVICE, AND OUR EMERGENCY ORDER PLAN.
3. LOW PRICES. ✓ 181

QUARTZ CRYSTALS FOR TWO-WAY — INDUSTRY MARINE — AMATEURS SCANNERS — CBs MICROPROCESSORS

JAN CRYSTALS

FOR FREE CATALOG, CALL OR WRITE:
JAN CRYSTALS
P.O. BOX 06017
FORT MYERS, FL 33906
(813) 936-2397

SINCE 1965 VISA MasterCard

TOLL-FREE: 1-800-237-3063
IN FLORIDA: 1-800-226-XTAL
FAX ORDERS: 1-813-936-3750

7/8-inch hardline coax connectors
construct your own at low cost

Increased Amateur use of the VHF and UHF bands has generated more interest in "hardline" coaxial cables because of their inherent low loss. Other articles have addressed one of the prime pitfalls of hardline use for Amateurs — coaxial connectors. Most discussions deal with connectors for CATV cable and develop methods for adapting UHF style connectors to this cable.[1-4] I'll deal with the modification of a commercially available "N" style connector for use on 7/8-inch, 50-ohm hardline.

7/8-inch hardline cable

Commercial 50-ohm hardline of the Heliax™ variety is quite expensive; if you can afford that, the cost of connectors is probably not a major concern. But, 7/8-inch Prodelin cable is available through a surplus dealer* for a fraction of the cost. The cable comes in any length up to 7500 feet and is made to rigid government tolerances with a thick, noncontaminating vinyl jacket that allows direct burial. (**Tables 1** and 2 list the hardline characteristics.) Though Prodelin™ cable is much cheaper than Heliax, commercial connectors can run $75 apiece. Because I wanted to use this high-grade 7/8-inch cable without the prohibitive expense of the mating connectors, I began to evaluate other alternatives.

connector "specs"

Requirements for any good connector include:
- minimal discontinuity in line impedance,
- no electrolytic action between dissimilar metals, and
- resistance to moisture penetration.[1]

An "N" style connector maintains excellent impedance matching and power handling properties at frequencies exceeding 450 MHz. UG-982 or UG-982/A connectors fit the requirements perfectly by providing a high-quality male "N" connector with a moisture resistant body that is easily adapted to 7/8-inch Prodelin-style hardline using simple tools. These connectors are common at hamfests and are also available from a number of sources.** Prices vary between $2 and $12 depending on source and condition.

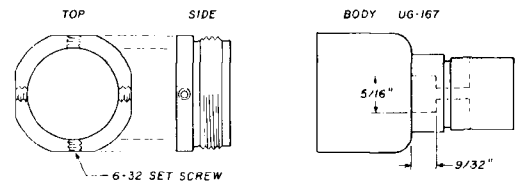


fig. 1. Construction drawing of the connector body.

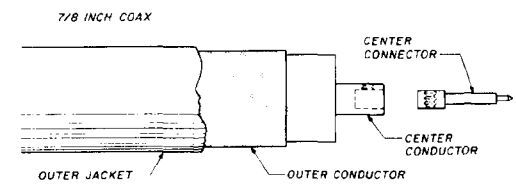


fig. 2. Drawing of the hardline indicating the modification of the center conductor to mate the center pin of the connector.

materials and tools

Table 3 lists the common tools (found at any hard-

* A.G.W. Enterprises, Inc., RD -10, Route 206, Vincentown, New Jersey, 08088.

**The R.F. Connection (Joel G. Knoblock, Proprietor), Suite 11, 213 North Frederick Avenue, Gaithersburg, Maryland 20877 and Nemal, 12240 NE 95 14th Avenue, N. Miami, Florida 33161.

By John M. Mathis, M.D., WA5FAC, 6270 Mt. Chestnut Road, Roanoke, Virginia 24018

Table 1. Physical and electrical properites of the Prodelin hardline

- 50-ohm impedance
- 7/8-inch aluminum corrugated shield
- Copper-clad aluminum solid center conductor
- Foam dielectric
- Black heavy-duty, noncontaminating outer jacket
- Can be directly buried

Table 2. Attentuation in dB/100 feet

Frequency (MHz)	RG8A/U-RG214/U	7/8-inch Hardline
3.5	0.30	0.10
7.0	0.45	0.14
14	0.66	0.19
21	0.83	0.23
50	1.35	0.37
144	2.5	0.70
220	3.3	0.90
450	4.8	1.3

Table 3. Materials

- Electric drill
- Rotary rasp (to be used with drill)
- Hacksaw
- Needle-nose pliers
- Pocket knife
- Soldering iron
- File
- 6-32-inch tap and no. 36 drill
- 7-32 and 9-32-inch drills
- Five 6-32 x 1/4-inch set screws
- Dremel tool and rotary saw blade (optional)

ware store) which were used to modify the connector and prepare the cable ends.

Refer to the construction drawings (**figs. 1** and **2**) during the fabrication procedure described below:

1. Cut through the black vinyl with a sharp knife. (I recommend wearing leather gloves.) Stabilize the cable with a clamp or vise. Grab the free end of the vinyl with a pair of needle-nose pliers and peel it off the aluminum outer conductor. Warming the vinyl makes this process easier. Remove about 1-1/2 inches of the black vinyl.
2. With a small hacksaw (or Dremel tool with rotary saw blade), cut through the corrugated aluminum shield 7/8 inch from the end. Try not to cut deeply into the foam dielectric. Now cut diagonally across the 7/8-inch section of shield. Peel the aluminum shield off the dielectric with a pair of needle-nose pliers (like opening a sardine can).
3. Using a pocket knife, remove the end 7/16-inch of foam dielectric from the center conductor.

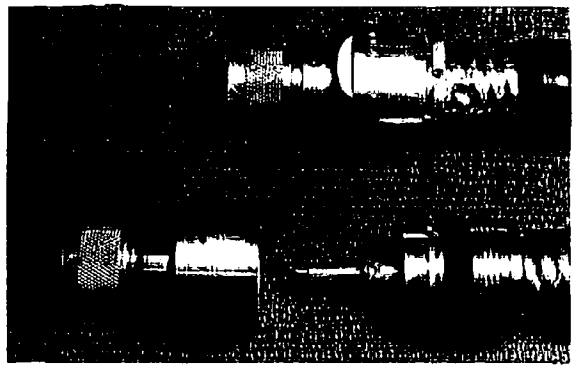


fig. 3. Partially and fully assembled connectors are pictured on 7/8" hardline coax.

4. With the 7/32-inch drill, center then make a hole 11/32 inch deep in the center conductor. Using a 9/32-inch drill, enlarge the proximal 1/16 inch of this hole leaving only the copper outer jacket of the center conductor.
5. Prepare the center pin by tapping the hole already present in the side collar to accept a 6-32 x 1/4-inch tap screw. Insert the tap screw until it contacts the opposite inner wall of the pin. With the soldering iron, fill the remaining hollow portion of the pin with solder. This stabilizes the otherwise thin wall of the pin and provides a pretapped hole for the set screw. Remove the set screw for now.
6. Hold the center pin alongside the center conductor and mark the location of the tapped hole. (Location may vary slightly with different manufacturers' pins.) Drill and tap this hole for a 6-32 inch also. Now insert the center pin into the center conductor. Align the set screw holes, insert the 6-32 x 1/4-inch set screw, and tighten. Fold the 1/16 inch of outer copper jacket over the pin body and solder the two together. (This will take at least a 150-watt iron.) *If you botch the job,* just cut the center conductor off and start again with step no. 2.
7. Locate the back collar of the UG-982; next we will

a flat edge every 90 degrees. Drill and tap each of these flattened edges for a 6-32-inch set screw.
8. Place the collar in a vise (the jaws of the vise should contact only the flattened edges, not the threaded portion). Don't overtighten the vise. With the rotary rasp, widen the inner diameter of the collar so that it fits snugly over the corrugated aluminum shield. Go slowly and check your progress often.
9. The connector is now ready for final assembly. Place the collar (with four 6-32 x 1/4-inch set screws) and moisture-proof "O" ring assembly over the cable. Slide on the main connector body and engage the threads between the connector collar and body. First tighten

the collar and body of the connector together; then secure the four set screws to the aluminum outer jacket. (**Figure 3** shows both partially and fully assembled hardline connectors.)

10. Waterproof the connector body and adjacent cable with 1-inch heat shrink. Silicone rubber* along the edges of the heat shrink finishes the job.

In my installation, I have 500 feet of 7/8-inch hardline between my shack and the top of my tower. Multiple measurements have revealed that the hardline, with adapted connectors, meets hardline specifications (table 2) with no measurable loss due to the connectors.

*GERTV 162-302 tubes are available from the **HAM RADIO** Bookstore for $9.95, plus $3.50 shipping and handling.

references

1. John H. Ferguson, W1IIM, "Connectors for CATV Coax Cable," *ham radio*, October 1979, pages 52-55.
2. Bud Weisburg, K2YOF, "Homebrew Hardline-to-UHF Coaxial Cable Connectors," *ham radio*, April 1980, pages 32-33.
3. James R. Yost, N4LI, "Plumber's Delight Coax Connector," *ham radio*, May 1981, pages 50-51.
4. Doug DeMaw, W1FB, "Connectors for CATV Hardline and Heliax," *QST*, September 1980, page 43.

Article N **ham radio**

NOVEX

DM4061 Dip Meter *every ham needs one*



A must for every ham shack - check coils, tank circuits, antennas, use as RF generator, internal modulation, look for harmonics. 1.5 - 250 MHz 6 plug-in coils
only $79.95 + $4 S&H

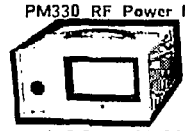
SWR-3P SWR/Power/Field Strength



- Measures output/SWR, while on the air
- 10 & 100 watt scales
- 1.7 to 150 MHz
- SO-239 connectors
- 5" whip antenna

only $19.95 +$4 S&H

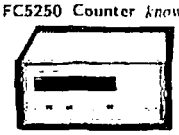
PM330 RF Power Meter/Dummy Load



- 1.8 to 500 MHz
- 50 ohm "N"
- 5/20/120 watt ranges
- measures your HF & HT power output

only $99.95 + $4 S&H

FC5250 Counter *know your transmit frequency*



- 10 Hz to 150 MHz
- 7 digit
- Accurate to ±1 count
- Gate time 1 or 5 sec
- HF & VHF inputs
- Excellent for audio
- AC power adapter PA9P included

only $129.95 + $4 S&H

Orders: 800-368-3270 Local & tech info 703 938 5330

EEB Electronic Equipment Bank
3516H Mill St NE, Vienna, VA 22180
(just minutes from Washington DC)

208

QRZ Contest!™
VHF Contest Software
for PC Compatibles
$39.95 postage paid
- Covers all VHF and UHF contests
- Includes the 70 MHz European band
- Menu driven and user friendly
- Color and options user configured
- Grids worked display on-line!
- Full dupe checking
- Complete log editor included
- Handles 4000 contacts with 512K
- Demo-version $5.00 (refundable with purchase of full program)
+ HF version to be available soon!

ATFAB Computers and Electronics
PO Box 4766, Maineville, OH 45039
(513)683-2042
VISA and Master Card Accepted

182

VISA ICOM MasterCard

VHF COMMUNICATIONS

INTRODUCING
W2DRZ VHF/UHF MODULES
NOW AVAILABLE

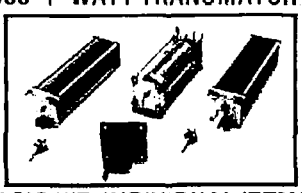
ICOM, AEA, LARSEN, VAN GORDEN, VIBROPLEX, NYE-VIKING, FALCON COMM, LEADING EDGE, ARRL PUBLICATIONS, KAGLO, HAMTRONICS, PROWRITER, ELEPHANT DISKS, DEBCO, TRIONYX

915 North Main Street
Jamestown, New York 14701

Western New York's first ... amateur radio dealer!
PH. (716)664-6345

183

1500 + WATT TRANSMATCH KIT $169.95



BASIC KIT: INDIVIDUAL ITEMS
1 - rotary inductor 28μh..... $59.00
2 - 6:1 ball drives.....$9.00 ea.
1 - 0-100 turns counter.....$65 75
2 - variable capacitors
25-245 pf 4500 v.....$44.00 ea

OPTIONS—
enclosure (pictured in Sept. 86 CQ).$64.00
4:1 balun kit.....$22.50
dials, terminals, chassis, ceramic standoffs, hardware, toroids, amp components, B&W coil stock, etc.

OTHER KITS
Article Reprints (refundable).....$1.50
G3RUH, PSK Packet Modem, Sat1./Terrestrial$99.00
PC Board for above only, delivered.....$27.99
Ten-Tec Designer Cabinet for above.....$12.00
K9CW Memory Contest Keyer.....$109.00
Yaesu FRG-9600, .1 to 60 MHz Converter....$94.95
20m CW, 15w Transceiver (H.R. 6/87).....$159.95
50W 75M SSB XCVR.....$199.95

Factory Wired
Nel-Tech DVK-100A (New Model).....$269.00
B & W PT-2500A Amp.....$1,670.00
B & W VS1500A Tuner.....$388.00
Amp Supply/Ameritron Linears.....CALL
Shipping Extra Unless Noted
Catalog $1.00

RADIOKIT • P.O. Box 973-H
Pelham, NH 03076 • (603) 635-2235

184

CONSTRUCTION TECHNIQUES USING PVC PIPE
TO MAKE ANTENNAS

By Van R. Field, W2OQI, 17 Inwood Road, Center Moriches, New York 11934

Support plus protection from the elements

PVC (polyvinyl chloride) pipe is a plumbing and electrical material that can be used to support, enclose, and seal antennas from the weather. Acid rain can cause antenna damage particularly in salt water areas. If you doubt you have a problem, hunt up an old corroded 2-meter beam, file a bright spot on each end of a director and apply your ohmmeter across the element. Try each element. I bet you'll find some open circuits.

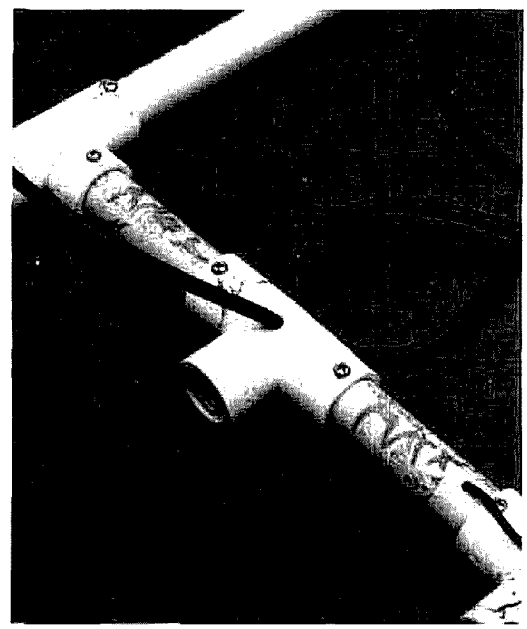
PVC pipe and its associated fittings make for easy construction of antennas with the added advantage of providing protection from the atmosphere. A plumbing supply house stocks many kinds. CPVC is the size and equivalent of copper tubing but is hard to find and will *not* fit regular pipe equivalent PVC.

In addition to the regular gluable PVC there is a gray threadable PVC. This is more expensive and not as handy. The glue-together white PVC is the best choice.

The pipe comes in different thicknesses. Schedule 40 is heavy duty, cold resistant, and the most common. In the South, thin wall schedule 20 is used — it's quite a bit lighter — a big advantage for antenna elements.

There is a full complement of plastic pipe fittings available for antenna construction: tees, elbows, caps, four-way junctions, to name a few. Larger diameter pipe can be used for hf verticals or masts. Short pieces make good insulators, feeder spreaders, and loading coil forms. PVC pipe can be cut with a hacksaw, a tubing cutter, or a special tool sold in plumbing supply houses.

You can use almost any type of copper wire inside the plastic pipe. I find no. 14 or no. 16 "enameled" solid wire the easiest to use. Put the end of a length in a vise, grab the other end with a heavy pair of pliers, and pull until the wire stretches or gives. This straightens the wire and allows it to be cut to size and worked easily. A good grade of twin lead works well, and is easier to keep in place inside the pipe.

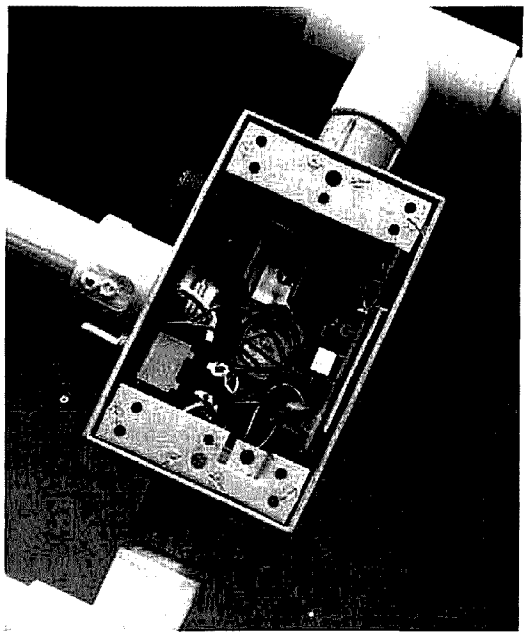


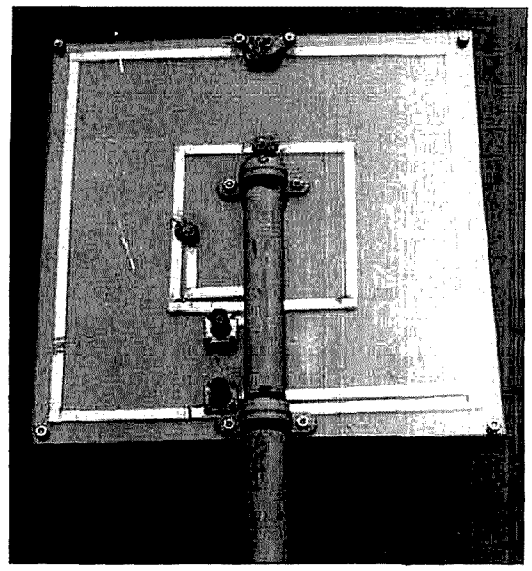
Styrofoam peanuts stuffed in the pipe and anchored with silicone rubber (RTV) will hold the wire in place. Thin string or lacing cord can be tied to the wire and held by the plastic pipe caps on the ends.

If you want to take it apart again, fasten the PVC pipe together with sheet metal screws. For a permanent job use the cement made for this purpose.

A mop handle will support your VHF antenna better than PVC because pipe is too flexible to hold a system of two or more elements. For portability, fit the end of the wooden support with an adapter (designated slip to male pipe thread). Then fit the center of your antenna with a tee-combination (slip x slip x female pipe thread); this will give you a threaded end on your support mast.

If you wish to install some electronics at the antenna, like a preamp or a doppler DF circuit, use a





waterproof outlet box with five threaded 1/2-inch holes. Purchase a box at an electrical supply outlet; a Mulberry no. 30221 or equivalent is needed. This cast aluminum box with its waterproof cover can be used at the center of the array to house the electronics and perform the job of a tee section. Electrical and plumbing supply houses carry threaded to slip joint transitions. The electrical (gray) ones thread into boxes easily.

PVC pipe has a velocity factor of 0.95. This has little effect on antenna length, but shortens a tuned stub an additional five percent when slipped into the PVC pipe. I tuned a twin lead J antenna for 157 MHz for a spare marine radio antenna. I inserted it into some schedule 40 PVC, rechecked, and found I had a 149-MHz antenna!

W6SAI demonstrated the use of PVC pipe for a collinear 2- meter antenna and a 160-meter vertical in his May 1987 column. Yagis for 432 MHz and above can be made of brazing rods stuck through a PVC boom.

I use a signal generator with a sensitive VSWR indicator to "VFO" around to find out where the VSWR dips. A frequency counter is tee-ed on the line to check the frequency accurately. An HT with extended frequency coverage may be used on low power for a signal generator.

This inexpensive, easy-to-use material gives the experimenter a good way to try out a new antenna.

Article 0 **ham radio**

K COMM., INC.
THE HAM STORE

Stocking all major lines. San Antonio's Ham Store. Great Prices—Great Service. Factory authorized sales and service. Hours: M-F 10-6, SAT 9-3

KENWOOD
YAESU
ICOM

5707A Mobud
San Antonio, TX 78238
800-344-3144
Orders Only ✓ 185

VISA MasterCard AMERICAN EXPRESS

THE RF CONNECTION
"SPECIALIST IN RF CONNECTORS AND COAX"

Part No.	Description	Price
321-11064-3	BNC 2 PST 28 volt coaxial relay, Amphenol Insertion loss: 0 to 0.75GHz, 0.10dB Power rating: 0 to 0.5GHz, 100 watts CW, 2 kw peak Isolation: 0.1 GHz/45db, 0.2 GHz/ 40db, 0.4 GHz/35db	$25 used tested
83-822	PL-259 Teflon, Amphenol	1.50
PL-259/ST	UHF Male Silver Teflon, USA	1.50
UG-21D/U	N Male RG-8, 213, 214, Amphenol	2.95
UG-21B/U	N Male RG-8, 213, 214, Kings	4.00
9913/PIN	N Male Pin for 9913, 9086, 8214 fits UG-21D/U & UG-21B/U N's	1.50
UG-21D/9913	N Male for RG-8 with 9913 Pin	3.95
UG-21B/9913	N Male for RG-8 with 9913 Pin	4.75
UG-146/U	N Male to SO-239, Teflon USA	5.00
UG-83/U	Female to SO-239, Teflon USA	5.00

"THIS LIST REPRESENTS ONLY A FRACTION OF OUR HUGE INVENTORY"

THE R.F. CONNECTION
213 North Frederick Ave. #11
Gaithersburg, MD 20877
(301) 840-5477 ✓ 186
VISA/MASTERCARD: Add 4%
Prices Do Not Include Shipping

SYNTHESIZED SIGNAL GENERATOR



MADE IN USA

MODEL SG-100F $429.95 delivered

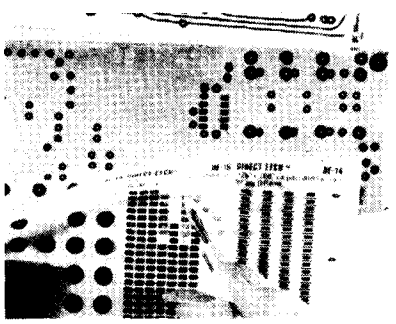
• Covers 100 MHz to 199.999 MHz in 1 kHz steps with thumbwheel dial • Accuracy +/– 1 part per 10 million at all frequencies • Internal FM adjustable from 0 to 100 kHz at a 1 kHz rate • External FM input accepts tones or voice • Spurs and noise at least 60 dβ below carrier • Output adjustable from 5-500 mV at 50 Ohms • Operates on 12 Vdc @ ½ Amp • Available for immediate delivery • $429.95 delivered • Add-on accessories available to extend freq range, add infinite resolution, AM, and a precision 120 dB attenuator • Call or write for details • Phone in your order for fast COD shipment. ✓ 187

VANGUARD LABS
196-23 Jamaica Ave., Hollis, NY 11423
Phone: (718) 468-2720 Mon. thru Thu.

NEW products

high quality printed circuit board

DIRECT ETCH™ is a new system for making high quality printed circuit boards without formal artwork. You can try different circuit layouts without changing the master art and refabricating. The system is useful for optimizing rf and microwave designs where wavelengths approach physical circuit dimensions, and in high impedance circuits. It's also easy to make a "quick and dirty" prototype where a printed circuit is not economical.



The DE-973 DIRECT ETCH™ set has 69 different sheets of plastic etch-resist patterns that transfer directly onto a copper-clad circuit board. The DE-973 costs $34.95; two sheet refill sets are $2.00.

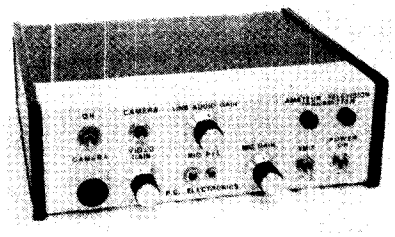
For details contact The DATAK Corporation, 3117 Paterson Plank Road, North Bergen, New Jersey 07047.

Circle #302 on Reader Service Card.

TX23 ATV transmitter

P.C. Electronics has introduced their model TX23 1-watt 23-cm (1240-1300 MHz) ATV transmitter. The small transmitter (7x7x2.5") lets Novice class or higher Amateurs transmit live action color or black and white composite video and audio from cameras, VCRs, or computers to other hams. The TX23-1 is a companion to the TVC-12G receiving downconverter.

The TX23-1 contains a 1-watt PEP (sync tip) transmitter, video modulator, and broadcast standard 4.5-MHz sound subcarrier. The unit comes with 1 crystal on the simplex frequency of 1289.25 MHz, or the customer can order one of the other ATV channels in the ARRL bandplan. A switch selects video and audio input from either the 10-pin VHS-type home color cameras on the front panel, or phono jacks for other cameras, VCRs, computers, and any composite video and line level audio source on the back. A mic jack and "push to look" (same as push to talk, but this is video) jack are available for low-impedance dynamic microphones and transmit/receive switching. The mic and line mixed audio levels have 2 independent volume controls, handy for voice over descriptions of home video tapes. The external power requirement is 12 to 14 Vdc at 600 mA, plus the 12-volt camera. The



antenna connector is a type N; a BNC outputs to the receiving downconverter from the built-in RF T/R relay.

The TX23-1's shielded cabinet will fit in a knapsack for portable work. The theoretical snow-free line-of-sight DX distance using the 1-watt TX23-1, TVC-23G downconverter, and 23 element Tonna beams, is 5 miles. The output power and sync-stretcher in the system's video modulator matches the 20-watt Downeast Microwave amplifier's linear input vs. output range.

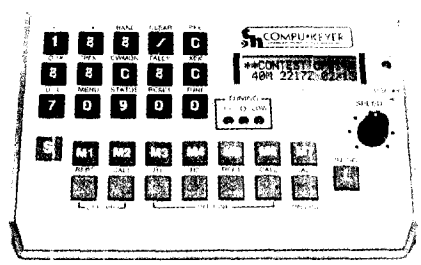
The TX23-1 transmitter is $299 delivered UPS surface in the contiguous United States. Another version of the transmitter, RTX-23, is available in a diecast aluminum box for use in repeater or link systems. For more information and a catalog, contact P.C. Electronics, 2522 Paxson Lane, Arcadia, California 91006.

Circle #303 on Reader Service Card.

TH-1 computer and two-keyer

Cire Electronic's new TH-1 Compu-Keyer is a state-of-the-art contest keyer and full-featured logging and duping computer.

The TH-1 is actually a computer and two keyers — one for stored messages and one for sending real-time messages from the key pad-



die. Each keyer is independent of each other and both can run simultaneously. This design feature allows you to send a pre-programmed report while entering the station's call and received report into the computer.

The computer uses a large array of static CMOS RAM and its memory is backed up by lithium batteries for fail-safe storage of pre-programmed messages and contest logs. A fully expanded memory allows for over 8,000 contacts per contest.

There is a RS-232 port that can be connected to either a terminal or printer to print the log. At the end of a contest, plug in your printer and enter a set of printer commands from the TH-1 keyboard for a finished, formatted, and dupe-checked printout of the log. For additional safety during a contest, a printer can be connected to the TH-1 to print all entries as they are logged.

The TH-1 can accomodate up to 8 operators, each with a bank of 7 messages and a pre-set offline-keyer speed control. Also included are a non-volitile clock and calendar, full RFI shielding, cartridge port for further expansion, large LCD display, and provision for external keyboard connection. A digital voice recorder for phone contests is in the prototyping stages.

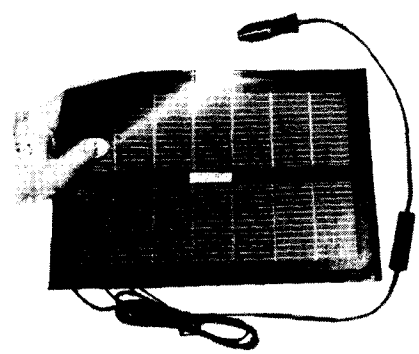
For more information, contact CIRE Electronics, 521 Leicester, Plymouth, Minnesota 48170.

Circle #304 on Reader Service Card.

let the sun do the work

Sovonics Solar Systems™, a subsidiary of Energy Conversion Devices, Incorporated, has introduced Sun Flex, Sun Pal, and Flexcharge™.

Products from the Sun Flex line can provide from 2 to 30 watts of power for everything from charging your RV or boat battery, to powering portable TVs and radios. The larger models can be used either singly or in arrays for increased power capabilities.



The Sun Pal series provides maximum power from minimum size. Any of the Sun Pal series, when folded for storage, take up the approximate space of a school notebook, but the 12 watt model provides enough power to run your radio — even on a partly cloudy day.

Sovonics also manufactures many other solar power related items.

For more information contact, Hal-Tronix, 12671 Dix-Toledo Highway, Southgate, Michigan 48195. Hal-Tronix is a registered dealer for Sovonics.

Circle #305 on Reader Service Card.

(continued from page 9)

Battery voltage and cell specific gravity were checked each day during that time and there was no significant difference between the two batteries.

As an additional testimonial, emergency power is supplied to our club repeater through a deep-discharge, marine-type lead-acid battery. The battery is maintained by a special charger. It has been sitting on bare concrete for about three years and still performs admirably when required.

It is a shame that such a good, worthwhile article was damaged by such a careless oversight. Please strive to maintain your excellent technical standards and avoid such errors in the future.

Kim Elmore, N5OP
Longmont, Colorado 80501

Dear Kim

Re: "Killer concrete strikes again." A possible explanation is that some acid had spilled over the surface of the battery and onto the floor which in essence established a conductive external path between the postive and negative terminals leading to premature battery death. I remember once measuring a quite finite resistance between any two points on the surface of a lead acid battery. Also what is the bulk resistivity of concrete? I don't believe it's infinite. Ed.

batteries on concrete

Dear HR:

Thank you for your rapid reply; it was refreshing and most appreciated! I would simply like to reiterate the point of my letter: there is nothing special about concrete as a mounting surface for a lead-acid battery. The scenarios you proposed do not, in any way, rely upon any quality inherent in concrete. The first, an acid spill, could occur on any type of surface. The acid solution, being an electrolyte, is a relatively good conductor and such circumstances could arise with any material. The second, surface conductivity along the battery case, could be caused by any (water-soluable) electrolytes on the battery surface. Acid is one, but any soluble salts will also act as conducting media in the presence of water. Many salts are hygroscopic and do not require the presence of "standing water" or a clearly wet surface; the water can be absorbed directly from the air. This is not to say that your explantions are invalid, but rather reiterate my point that concrete is not a special or requisite component in lead-acid battery discharge.

This doesn't mean is isn't a wise idea to place a lead-acid battery on something. Any acid spill can be catastrophic, depending on what it contacts. However, there is nothing inherently wrong with placing a lead-acid battery directly on a concrete surface.

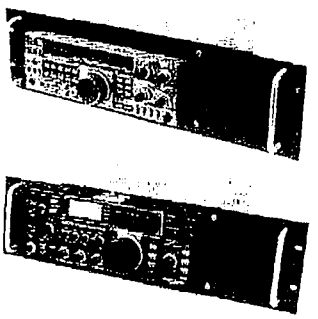
By the way, at no point in my letter did I state that concrete had infinite resistivity. I stated: "Because a battery is contained within an insulating enclosure, there can be no electrical current between whatever it sits upon and the internal cells." If taken literally, that statement is false because "no electrical current" implies infinite resistivity. However, from an engineering standpoint the statement is accurate. From the arguments presented above — and in my previous letter — the resistivity of the substance the battery sits on, from an engineering standpoint, is of no consequence.

In any event I could not find, in any handy reference, a value for the bulk resistivity of concrete other than: "Completely dry concrete has a very high resistivity, but extensive tests have shown that when concrete is embedded in earth so that moisture can penetrate it, its resistivity is about the same as that of the surrounding soil and follows its seasonal variations." (R.H. Golde, Editor, "Lightning, Volume 2: Lightning Protection," Academic Press, Inc., New York, New York 1977, page 588.)

Thank you again for your response and attention in this matter. Keep up the good work; I enjoy *ham radio* very much.

Kim Elmore, N5OP
Longmont Colorado 80501

NEW SUPER LONG PLAY TAPE RECORDERS
12 Hour Model — $105.00*
USES D-120 TAPE
Modified Panasonic Slimline. high quality, AC-DC Recorders provide 6 continuous hours of quality recording & playback on each side of cassette for a total of 12 hours. Built-in features include • Digital counter, etc. TDK DC 120 Cassette Furnished.
PHONE RECORDING ADAPTER
Records calls automatically. All Solid state connects to your telephone jack and tape recorder. Starts recording when phone is lifted. Stops when you hang up. $24.50* FCC APPROVED
VOX VOICE ACTIVATED CONTROL SWITCH
Solid state. Self contained. Adjustable sensitivity. Voices or other sounds automatically activate and control recorder. Uses either recorder or remote mike. $24.95*
*Add for ship & hdlg. Phone Adapter & Vox $1.50 ea. Recorders $4.00 ea. Cal. Res. add tax. Mail order, VISA, MC, COD's OK. Money Back Guarantee. Qty. disc. avail., Dealer Inquiries Invited. Free data. ©
AMC SALES INC. Dept H 9335 Lubec St., Box 928, Downey, CA 90241 Phone (213) 869-8519
189

THE RACK IS BACK
GO VERTICAL

• save space — go vertical
• organize your radio room
• get the professional look
• have finger tip access to your radios
• keep your equipment safe and clean
• hide all the unsightly wires
• protect your investment
NOVEX rack mounts are standard EIA 19 inch size aluminum panels and are optionally equipped with handles and/or forward facing speakers.
Now available for most ICOM, KENWOOD, and YAESU radios and accessories.
Prices start at a low $79.95 each.
EEB
Orders: 800-368-3270
Electronic Equipment Bank
5161 Mill St. NE, Vienna, VA 22180
189



(continued from page 6)

ience of putting up temporary antennas and solving emergency power and RFI problems, all adds up to very valuable training. This is true even though it was all planned weeks in advance. The military trains constantly for situations that must eventually be handled instantly.

In the twenty years I've been doing Field Day, only one group I was with was seriously concerned with winning the contest. Don't get me wrong, if that's what they want to do, that's their perogative. It's tough to get overly serious about a contest when you are at the top of Tuscarora Summit in South Central Pennsylvania with the Chambersburg Club watching the sun rise Sunday morning as you cook breakfast (I'd like to go back there again.) As for the assumption that clubs use only their best operators to run off thousands of "Qs" in an all out effort to win — my guess is that's a very small percentage of the overall participation. This year we got a number of our group on the air who just don't operate that much. These hams all had fun — and that is what Field Day is all about.

Why not use another event like the Simulated Emergency Test (or make one up) to really measure the ability for true emergency communications capabilities. Make it a 12-hour event to minimize disruption to the family and de-emphasize scoring. Leaving the rest of your proposal intact, we could truly test Amateur's ability to communicate in an emergency situation.

Leave Field Day alone. It's too much fun now as it is. I'd hate to miss one due to a show, vacation, or other previously scheduled commitment.

Craig Clark, N1ACH

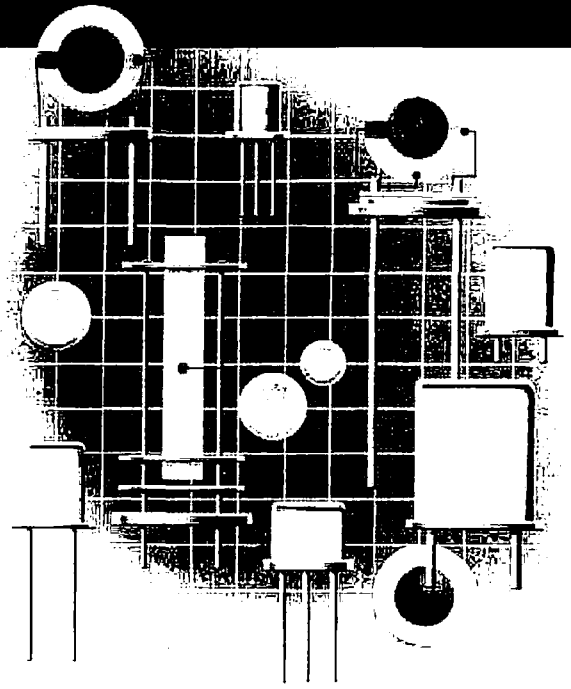
CUSTOM CRYSTALS

Crystals for many applications

For over 37 years, ICM has manufactured the finest in quartz crystals for every conceivable purpose.

A wide selection of holders are available to fit most any requirement. Our computer database contains crystal parameters for thousands of equipment types.

Need crystals for communications, telemetry, industrial, or scientific applications? Let ICM's sales department assist you to determine which type of crystal is best for you.



Can we solve your crystal problem?

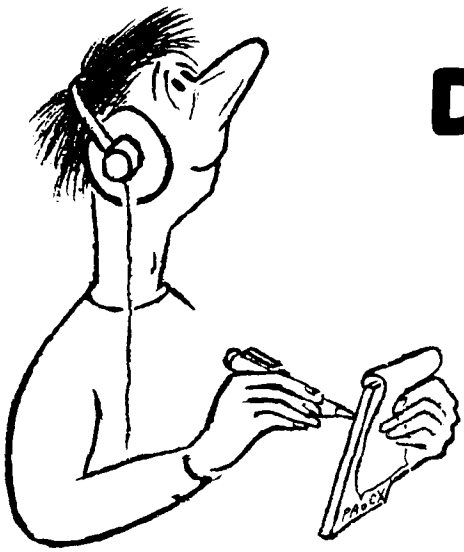
For special purpose crystals, special holders, special sizes, call our crystal sales department. We will be pleased to provide recommended data.

ICM

International Crystal Manufacturing Co., Inc.

P.O. Box 26330, 701 W. Sheridan,
Oklahoma City, OK 73126-0330
Phone (405) 236-3741
Telex 747-147
Facsimile (405) 235-1904

212



DX FORECASTER

Gerth Stonehocker, KØRYW

high sunspot propagation problems

The sunspot numbers in cycle 22 are now high enough to increase the probability of major flares. These flares lead to a sequence of propagation problems. Understanding the sequence and its timing helps when working DX; knowing what to expect and what action or remedy to take will help alleviate the poor signal. When a sunspot or filament (demarcation between sunspots or regions) flares, a burst of energy erupts sending electromagnetic radiation and particles out from the sun. The burst of energy in its various forms arrives at the earth's ionosphere at different times, each form causing unique propagation effects. Three main propagation effects (events) occur in a sequence as shown in **table 1.**

The sudden ionospheric disturbance, SID, is an abrupt increase in the absorption of the signal's energy in the D region. It is caused by the increased light (ultraviolet) and x-rays entering the earth's atmosphere immediately following the sun's flare. The light that reaches us 8 minutes later indicates there is a flare on the sun. This absorption resembles what you see at sunrise. It is greatest directly under the sun (subsolar point, noon standard time) and decreases in all directions. SID events don't occur on your path after sundown. The signal usually loses strength (many 10's of dB for large events) in about 5 to 15 minutes. Then there is a slow recovery period of 20 minutes to an hour or two before signal strength returns to normal. SID's signal loss and duration increase with flare size and duration.

You might *find it interesting to look* at the portion (longitudes) of the world affected by a SID on a world time "wheel" calculator. Set the wheel dial (time of flare from WWV at 18 minutes after the hour) to Greenwich, London, 0° longitude. Then look around the wheel dial from 06 to 18 hours on the noon side, not a.m. and p.m. These are the longitudes where the propagation path would experience SID; the greatest SID effect occurs at 12 noon. The midnight side of the wheel dial from 18 hours to 06 hours wouldn't have SID.

What should you do if you're working DX when a SID comes? You can go to the highest band propagating to the DX's location, use an alternate propagation path, or just wait it out on frequency until signals return in a half hour or so.

Polar cap absorption, PCA, also causes signal loss as the signal passes through the lower ionosphere, but only inside the auroral zone in the polar cap. Protons are the most energetic particles emitted from sunspots during a flare. They are numerous and fast enough to increase solar wind density and speed, and are the first particles to reach the earth. They can't get here directly as do x-rays and light because they can't cross perpendicular to the earth's magnetic field lines. Only those *parallel to the* field lines may enter the atmosphere so they enter at the poles, coming down the field lines into the ionosphere. Once there, they cover the polar cap during the daytime. A location outside the sunlit polar cap may experience some darkness during the 24-hour period so the absorption of the signal will stop until the daylight hours return. This cycle repeats over the next 1 to 3 days until the disturbance ends. The duration and the number of dBs of PCA absorption depend not only on flare size and duration, but also on its solar location to feed the solar wind and the particular proton-producing characteristic. The only propagation paths affected are those crossing the polar cap in the sunlight. (Remember the seasonal aspect of night and day above 66° north or south.) The PCA is limited in the propagation paths that are affected. The higher frequencies are limited over the pole; taking an alternate direction or waiting until darkness may be the only remedies if a PCA occurs while DXing. The most complicated of the three effects in the

TABLE 1

Three main propagation events caused by major solar flares.

Event	Cause	When/Where	Duration
SID	Ultraviolet light and x-rays	Immediate in daylight	1/2 to 2 hours
PCA	Proton particles	Polar daylight in 1 to 10 hours	1 to 3 days (daylight)
Fade-out	Electron particles	Auroral zone south in 1 to 3 days (mainly nighttime)	1 to 3 days

SEPTEMBER

WESTERN USA

GMT	PDT	N	NE	E	SE	S	SW	W	NW
0000	5:00	20	30	20	10	12	10	10	12
0100	6:00	15	30	20	12	12	10	10	15
0200	7:00	15	*30*	20	12	12	10	10	15
0300	8:00	20	*40*	*20*	15	15	10	10	15
0400	9:00	20	*40*	*20*	15	15	10	12	20
0500	10:00	30	30	20	20	20	12	12	20
0600	11:00	30	30	20	20	20	12	12	20
0700	12:00	30	*30*	20	*20*	20	15	15	30
0800	1:00	30	*30*	*20*	*20*	30	15	15	30
0900	2:00	*30*	*40*	*20*	*20*	*30*	15	15	30
1000	3:00	*40*	*40*	*20*	*20*	*30*	15	20	30
1100	4:00	*40*	30	*20*	*20*	*30*	20	20	*30*
1200	5:00	*40*	20	15	*20*	*30*	*20*	*20*	*30*
1300	6:00	20	20	12	15	*30*	*20*	*20*	*30*
1400	7:00	30	15	12	15	*30*	*20*	*20*	*30*
1500	8:00	30	15	10	12	20	*20*	20	*30*
1600	9:00	30	15	10	12	15	*20*	*20*	*30*
1700	10:00	30	15	10	12*	15	*20*	*20*	*30*
1800	11:00	30	15	10	10	15	15	*20*	30
1900	12:00	*40*	20	12	10	12	15	15	20
2000	1:00	*40*	20	12	10	12	12	15	20
2100	2:00	*40*	20	12	10	12	12	12	15
2200	3:00	20	30	15	10	12	10	12	15
2300	4:00	20	30	15	10	12	10	10	12

MID USA

MDT	N	NE	E	SE	S	SW	W	NW	CDT
6:00	20	30	20	12	12	10	10	15	7:00
7:00	20	30	20	12	12	10	10	15	8:00
8:00	30	*40*	20	15	15	10	10	20	9:00
9:00	20	*40*	*20*	15	15	12	12	20	10:00
10:00	30	*40*	*20*	20	20	12	12	20	11:00
11:00	30	*40*	*20*	20	20	12	12	30	12:00
12:00	30	30	20	20	20	15	15	30	1:00
1:00	*30*	30	*20*	*20*	30	15	15	30	2:00
2:00	*40*	*40*	*20*	*20*	*30*	15	15	*30*	3:00
3:00	*40*	*40*	*20*	*20*	*30*	20	20	*30*	4:00
4:00	20	*40*	20	*20*	*30*	20	20	*40*	5:00
5:00	20	30	15	*20*	*30*	*20*	*20*	*40*	6:00
6:00	20*	20	12	*20*	*30*	*20*	*20*	30	7:00
7:00	20	15	12	20	*30*	*20*	*20*	30	8:00
8:00	20	15	10	15	20	*20*	20	30	9:00
9:00	30	15	10	15	15	*20*	20	*30*	10:00
10:00	30	15	10	12	15	20	*20*	*30*	11:00
11:00	30	15	10	12*	15	15	*20*	*30*	12:00
12:00	30	20	10	10	12	15	*20*	30	1:00
1:00	*30*	20	12	10	12	12	15	20	2:00
2:00	*40*	20	12	10	12	12	15	20	3:00
3:00	*40*	20	12	10	12	12*	12	15	4:00
4:00	*40*	30	15	10	12	10	12	15	5:00
5:00	20	30	15	10	12	10	10	15	6:00

EASTERN USA

EDT	N	NE	E	SE	S	SW	W	NW
8:00	20	30	20	12	12	10	10	20
9:00	30	40	20	12	12	10	12*	20
10:00	30	*40*	20	15	15	12	12	30
11:00	30	*40*	*20*	15	15	12	15	30
12:00	30	*40*	*20*	20	20	15	15	30
1:00	*30*	*40*	*20*	20	20	15	15	30
2:00	*40*	*40*	*20*	*20*	30	20	20	*30*
3:00	*40*	*40*	*20*	*20*	30	20	20	*30*
4:00	*40*	30	*20*	*20*	*30*	20	20	*40*
5:00	20	20	20	*20*	*30*	*20*	*20*	*40*
6:00	20	20	15	*20*	*30*	*20*	*20*	30
7:00	20	20	12	20	*30*	*20*	*20*	30
8:00	15	15	12	15	*30*	20	20	30
9:00	20	15	10	15	*30*	20	20	30
10:00	20	15	10	12	20	*20*	20	*30*
11:00	30	15	10	12	15	*20*	20	*30*
12:00	30	15	10	12	15	*20*	*20*	*30*
1:00	30	15	10	12*	15	20	*20*	*40*
2:00	30	20	10	10	12	15	*20*	30
3:00	*30*	20	12	10	12	12	15	20
4:00	*30*	20	12	10	12	12*	12	20
5:00	*40*	20	12	10	12	10	12	15
6:00	*40*	30	15	10	12	10	10	15
7:00	20	30	15	10	12	10	10	15

	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
MUF	20	30	15	10	12	10	10	15

	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
MUF	20	30	15	10	12	10	10	15

	ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
MUF	20	30	15	10	12	10	10	15

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next higher band for possible openings.

sequence, the fade-out, will be discussed next month.

last-minute forecast

The higher frequency 10 to 30-meter bands (the daylight bands) should be very good the first and last two weeks of September. The probability of transequatorial one-long-hop late evening (to 2200 local time) openings to southern countries should start to increase. Sporadic E short-skip openings, however, will probably become scarce. Transequatorial openings may be enhanced during the equinox seasonal Increase in geomagnetic disturbances expected around the 1st, 8th, 21st, and 27th. The lower frequency nighttime bands should be best the second and third weeks of the month. Look for DX from unusual countries in east-west directions during the disturbances listed. Lower thunderstorm noise later in the month (except during fall weather frontal passages) should help the signal get through. The full moon and its perigee will fall on September 25. The autumnal equinox occurs on the 22nd at 1929 UTC. There will be an annual eclipse of the sun on September 11 from 0200 in East Africa, across South Asia, Indonesia, and New Zealand, ending in Antarctica at 0730 UTC.

band-by-band summary

Ten, 12, 15, and 20 meters provide many openings during the daytime. As you go up in frequency the openings will be shorter, centered around noon, and mainly in southerly directions. Fifteen meters is only a transition band between 12 and 20. Twenty meters, the mainstay daytime band for northerly directions, will be useful towards the south in the evenings.

Thirty, 40, 80, and 160 meters are all good for nighttime DX. Thirty and 40 meters are the night frequencies for the east-west and northerly directions, and for distances of 1600 miles if increased solar activity has occurred. With little solar activity so far, the MUF will approach 80 meters and signals will usually be stronger.

ham radio

ALL BAND DIPOLE TRAP ANTENNAS!

PRETUNED-ASSEMBLED ONLY ONE NEAT SMALL ANTENNA FOR ALL BANDS! EXCELLENT FOR APARTMENTS! IMPROVED DESIGN! FOR ALL MAKES AMATEUR TRANSCEIVERS! GUARANTEED FOR 2000 WATTS SSB INPUT FOR NOVICE AND ALL CLASS AMATEURS! CW-AM-FM

COMPLETE with 90 ft. RG58U-52 ohm feedline, and PL259 connector, insulators, 30 ft. 300 lb. test dacron end supports, center connector with built in lightning arrester and static discharge, sealed, weatherproof, traps - 1"X5" wt 3 oz. Low SWR over all bands -Tuners usually NOT NEEDED! Can be used as inverted V's - slopers - in attics, on building tops or narrow lots. WORKS ON NEW WARC BANDS! The ONLY ANTENNA YOU WILL EVER NEED FOR ALL BANDS! NO BALUNS NEEDED!

160-80-40-20-15-10 -- 4 trap- 169 ft. No. 1060E . $134.95
80-40-20-15-10 -- 2 trap - 104 ft. - No. 998E $99.95
40-20-15-10 -- 2 trap -- 54 ft. - No. 1001E $99.95
20-15-10 meter - 2 trap - 26 ft. - No. 1007E $97.95

SEND FULL PRICE FOR PP DEL. IN USA. (Canada is $5.00 extra for postage etc) order using VISA - MASTER CARD - AMER. EXPRESS. Ph 1-308-236-5333 week days. We ship in 2-3 days. (Per Ck's 14 days) All antennas guaranteed for 1 year. 10 day money back trial if returned in new condition! Made in USA. FREE INFO. AVAILABLE ONLY FROM

WESTERN ELECTRONICS
Dept. AH Kearney, Nebraska, 68847

✓ 194

The entire back issue file of **Ham Radio Magazine** and **Ham Radio Horizons** is now available on easy to read, microfiche. The entire set (March 1968 thru December 1987, and March 1977 thru December 1980, respectively), is now available in one, easy to use format! Everything from front to back cover (ads too). Annual updates will be offered for $10.

Ham Radio - $150.00
HR Horizons - $35.00
($5 shipping per order, USA)

Your satisfaction guaranteed, or money back.

Send or call order to:

Buckmaster Publishing
Post Office Box Ten
Mineral, Virginia 23117
(800) 282-5628
(703) 894-5777

VISA/MC accepted

SPECIALISTS IN FAST TURN P.C. BOARDS

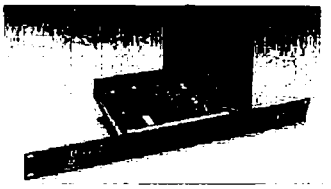
PROTO TYPE P.C. BOARDS
AS LOW AS $25.00
- SINGLE & DOUBLE SIDED
- PLATE THROUGH HOLES
- TEFLON AVAILABLE
- P.C. DESIGN SERVICES

FOR MORE INFORMATION

Midland Technologies
34374 EAST FRONTAGE ROAD
BOZEMAN, MT 59715 (406) 586-1190

✓ 196

Factory-less, jumper-less, ROM-less programming.



With the new **S-COM 5K** Repeater Controller, you'll be able to configure your repeater remotely — using DTMF commands. Only the **5K** offers this capability for just $189, wired and tested.

S-COM INDUSTRIES
S-COM Industries
P.O. Box 8921
Fort Collins, CO 80525
(303) 493-8316

✓ 197

NEW!
The classic "Antenna Bible"
now in a thoroughly-revised, much-enlarged edition
ANTENNAS
2nd edition
by John Kraus, W8JK
Ohio State University

Covers both theory and its applications to practical systems. Over 1000 illustrations and nearly 600 worked examples and problems. Over 100 new topics. Complete with design formulas, tables and references

917 pages, hardcover. $51.95

Add $2.50 per book for shipping and handling U.S., $5.00 elsewhere.

CYGNUS-QUASAR BOOKS
P.O. Box 85, Powell, Ohio 43065
Tel. 614-548-7895

✓ 198



ELMER's NOTEBOOK

Tom McMullen, W1SL

the mysterious "Q"

A sometimes mystifying concept for many Amateurs is a thing called "Q". It has a habit of appearing in questions, theory discussions, and product descriptions. Sometimes it's met with mild curiosity; at others it's given moderate study and passed over in hopes that it will never be needed.

It doesn't need to be treated that way. True, a circuit designer must know how to toss jargon around with ease, and put the idea into practice to achieve a desired result. For the rest of us, a basic understanding of what Q does is sufficient and not all that difficult.

so, what is Q?

Reduced to basics, Q is a measure of quality. When textbooks speak of the Q factor, they are talking about the quality factor of some component or circuit. It's a measure of how well a circuit performs — or more simply, how much loss there is in the circuit and its components.

When referring to components, things that affect Q are the type of dielectric in a capacitor and the wire size and material in an inductor. This includes the form (if any) the coil is wound on, and any conductive or nonconductive objects within its magnetic field.

All of *these losses* affecting Q are ac losses; the actual dc loss because of wire resistance is usually low enough to be ignored. At radio frequencies, however, losses can mount up and do contribute to lowered Q in resonant circuits.

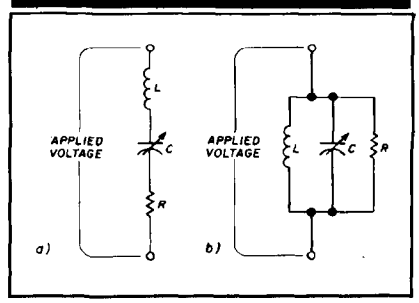
more is not always better

At first glance, it would seem that higher quality (higher Q) would be the thing to strive for. After all, the less energy we lose the better, right? Not always. It depends on where the circuit is to be used. A high-Q circuit placed in the output of a transmitter will sometimes cause an air-dielectric capcitor to arc over, or heat a solid dielctric enough to make it break down and cause a short circuit. The solution is to tailor the Q of a transmitting circuit for the best compromise between losses, no breakdowns, and circuit bandwidth (more about bandwidth later). The energy involved in a receiver circuit isn't great enough to cause arcs or dielectric breakdown, so high-Q circuits are permitted. In fact, this is where high-Q circuits do their best by providing needed selectivity in different sections of the receiver.

what determines Q?

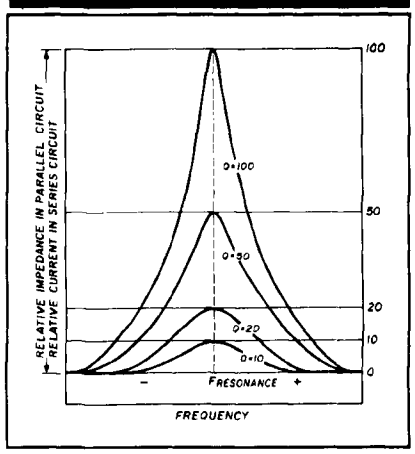
The Q of a resonant circuit is affected by the losses in the components that make up the circuit: dielectric losses in capacitors, wire skin resistance, and some dielectric effects in coils. The schematic in fig. **1A** shows a series-tuned circuit with its loss (R) in series with the inductor and capacitor. This is the functional equivalent of the parallel circuit of **fig. 1B** which has the loss (R) in parallel with the inductor and capacitor. Either circuit tunes very sharply if there are no losses and a

FIGURE 1



(A) A series-resonant circuit with losses (R) shown in series with the inductor and capacitor. (B) A parallel-resonant circuit with the loss (R) in parallel with the tuned circuit.

FIGURE 2



Frequency response curves of tuned circuits with different Q factors. The lower the Q, the more broad the frequency response. A high Q translates to high impedance across a parallel circuit and high current through a series circuit.

curve at resonance might look like the one shown as Q = 100 in **fig. 2.**

The resistance (R) in both circuits is caused by component losses, but it will absorb energy and dissipate it as heat just as if the energy were dc and the resistor a normal carbon resistor connected in the circuit. Because the losses dissipate some of the energy in the circuit, the quality (Q) of the circuit is lower. Some examples are shown in the curves of **fig. 2** marked Q = 50, Q = 20, and Q = 10.

Here's a simple experiment you can perform with a grid-dip meter to see the difference between high- and low-Q circuits. Almost any dip meter will do. Wind a coil of perhaps 15 turns of enameled wire on a small form; a diameter of 3/8 to 1/2 inch diameter will do. Select a small trimmer capacitor in the range of 10 to 50 pF and connect it across the coil. Place the tuned circuit on a nonconductive surface (wooden table or a couple of books), bring the dip meter close and find the circuit's resonant frequency. When the dip meter is very close, you'll notice that the dip is deep and sharp and that the tuned circuit "pulls" the meter's frequency over a considerable range. Move the meter away from the circuit slowly until you find the place where the dip is just noticeable. Mark the position of the meter and the tuned circuit. Next, connect a resistor across the tuned circuit — try about 2200 ohms, 1/2 watt for starters — and make sure it is carbon composition or carbon film. Place the tuned circuit back in the same position, bring the dip meter up close, and find the resonant frequency again. You can adjust the trimmer until the frequency is the same as before. Note the difference in response of the dip meter; the dip should be much less sharp. Move the meter away until the dip *is* again just noticeable. You'll find the distance is much smaller.

The losses you just added to the circuit lowered its Q in the form of a resistor dissipating energy. Where is the energy coming from? It is being induced in the circuit by the magnetic field from the dip meter. This induced energy flowing through the coil creates a magnetic field of its own, which is maximum at resonance and then reacts with the tuned circuit in the dip meter. This reaction is shown as a dip (decrease) in energy in the dip meter — and that's what makes a dip meter work.

If you want to experiment some more, connect the resistor in series with the LC combination and find the resonant frequency again while noting the response of the dip meter. Try different values of resistance, both in parallel and in series with the circuit. You'll note that a lower resistance in series with the LC permits a higher Q, but has just the opposite effect in a parallel arrangement.

practical applications of Q

As mentioned earlier, a high-Q circuit in a transmitter is a "no-no." One of the interesting things about tuned circuits and Q is that the effective voltage across a circuit can be much higher than the applied voltage. It's not unusual for a transistorized circuit that has a dc voltage of 12 volts to develop an rf voltage in a resonant circuit of 40 or 50 volts if the external loading is light.

A common setup in many Amateur stations is a transmitter feeding 200 watts into a 52-ohm coaxial transmission line. That amount of power develops approximately 102 volts across the coax ($E = \sqrt{P \times R}$). If this is applied to an antenna coupler (tuner) with a Q of 50, the tuned circuit can develop 5100 volts across the coil and capacitor ($E_{circuit} = Q \times E_{applied}$). Aside from the *good* practice of not causing QRM when tuning up your transmitter/antenna coupler, this is another reason to make all the adjustments at low power. Who needs the sound and aroma of things frying while you try to get the proper loading!

Loading can consist of several things. The device (tube or transistor) providing power to the circuit will load it and lower the Q, as will the next stage in a transmitter, or an antenna coupler, feedline, and antenna. The lighter the loading, the higher the unloaded Q. (Unloaded Q is referred to by those in the know as Q_u; loaded Q is written as Q_L.)

People who design transmitter circuits work out a compromise that matches the transistor or tube with the necessary impedance, provides an impedance transformation to feed the next stage, and does a reasonable job of rejecting unwanted signals. A high-Q circuit is great at rejecting harmonics or any other signal that is not at the resonant frequency. As the Q is lowered, through losses or by design, the harmonic rejection also decreases until at some point the circuit is not selective. The bandwidth of the circuit can be calculated by the formula Bandwidth(-3 dB) $= F_o/Q$, where F_o is the frequency of resonance. This means that if the curves in **fig. 2** are plotted on a frequency and dB scale, the two points at which they intercept the 3-dB down curve (half power, or -3dB) will indicate the circuit's selectivity (determined by the bandwidth at the -3dB points).

Today's multiband, broad-banded transceivers can have transmitter circuits made up of several tuned circuits, precisely tailored to provide a match between the output device (transistor or tube) and the antenna circuit over a specific range of frequencies. They can also be designed to attenuate harmonics, minimizing interference to other services. This is an area where a knowledge of Q and impedance matching is valuable to designers.

Receivers, on the other hand, require a different approach. An important function of Q in receiver circuits is to reject signals that are either outside the band or just a few kHz away. In a typical bandpass design, selectivity in the rf amplifier stages can be tailored to cover just the Amateur band and reject signals that are more than a few kHz outside. This requires several circuits with just the right amount of Q and correct coupling between them to pass a "band" of frequencies.

When it comes to rejecting signals within the band, the i-f circuits do their thing. Sharply tuned circuits with low

losses (high Q_u) are one approach. Many receivers use either mechanical filters, crystal filters, or ceramic resonators to achieve the required result. All of these devices have a very high Q, which means they do an excellent job of rejecting off-resonance signals. But if this is carried too far, as in very narrow filters for CW use, the energy stored in the circuit tends to stay there so long that it produces a sort of echo (called ringing) and makes life difficult in the high-speed lane.

calculating Q

I've left this part for last to prevent scaring anyone who's allergic to formulas, but they're really not that bad. The basic Q_u can be calculated by:

$Q_u = X/R_s$

where: Q_u = quality factor (unloaded)
X = reactance of either L or C in ohms (remember that they are equal and opposite in a tuned circuit at resonance)
R_s = series resistance (loss) in ohms
Loaded Q is calculated by:

$Q_L = R_p/X$

where: Q_L = quality factor (loaded)
R_p = parallel load resistance in ohms
X = reactance in ohms

In summary, Q is a concept that can be used as a tool to design matching circuits, bandpass filters, band-reject filters, signal traps, interstage coupling and matching, and many other important parts of the radio world. It needn't be regarded as a mysterious entity lurking in the theory books just waiting to trip you up. It's simply a part of the language of electronics alongside R, E, I, and all the rest.

Article P **ham radio**

DIRECT DIGITAL SYNTHESIZER

DIGITAL RF SOLUTIONS INC. offers a high performance, low cost direct digital synthesizer to the readers of Ham Radio. Once available only for military and other high cost systems, DRFS has made DDS affordable for the serious Amateur experimenter. For technical details of this synthesizer consult, "A Direct Digital Synthesis VFO" elsewhere in this issue.

We are now offering the DX2070 circuit board to advanced experimenters. The DX 2070 board comes assembled and tested and can be used for a wide variety of frequency-agile synthesizer applications, including many for Amateur Radio. NOTE: This unit should not be regarded as an Amateur Radio "kit". It is for experimental work only. Only Amateurs with access to a comprehensive RF lab (particularly a spectrum analyzer) should consider purchasing this unit. DX2070 has 70 dB typical spurious levels.

Regular price of the board $895.00

DIGITAL RF SOLUTIONS, INC.
3080 Olcott Street - Suite 200d
Santa Clara, CA 95054
(408) 727-5995
Outside CA: (800) 782-6266 ✓ 195

1988 CALL DIRECTORY
(on microfiche)

Call Directory	$8
Name Index	$8
Geographic Index	$8

All three - $20 Shipping per order $3

BUCKMASTER PUBLISHING
Mineral, Virginia 23117
703-894-5777
800-282-5628

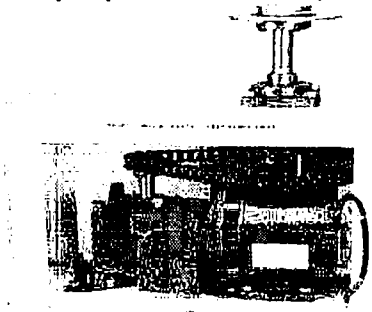
✓ 202

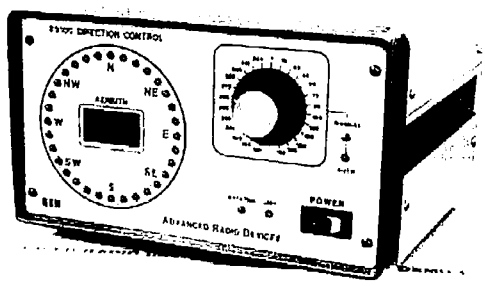
R9100 *SUPER ROTATOR*

The Advanced Radio Devices (ARD) R9100 is the heavy duty antenna rotator designed for the big gun with antenna loads to one ton. All components are designed and selected for durability and long life, a quality often over looked.

The control system provides both analog and digital readout of direction to within ±1 degree. Provisions for external computer control which allows rotor positioning by the mere keyboard entry of a target country's prefix. Software is provided for use with most popular computers.

This quality rotor is the most capable and powerful unit designed for the amateur market today. You can pay more and get less.





SPECIFICATIONS
Rotating torque: 10,000 inch lbs.
Braking torque: 24,000 inch lbs.
Vertical load: 2000 lbs.
Mast sizes: 2.0 to 3.5 inch O.D.
Motor: 1/3 HP
Rotation speed: 1 RPM
Weight: 230 lbs.
Size: 14.9x25x15.1 inches (wlh)

Write for complete specs and installation information

Distributed Exclusively by EEB

EEB
Orders: 800-368-3270
Local & tech info 703-938-3350
Electronic Equipment Bank
516H Mill St. NE, Vienna, VA 22180
(just minutes from Washington, DC)

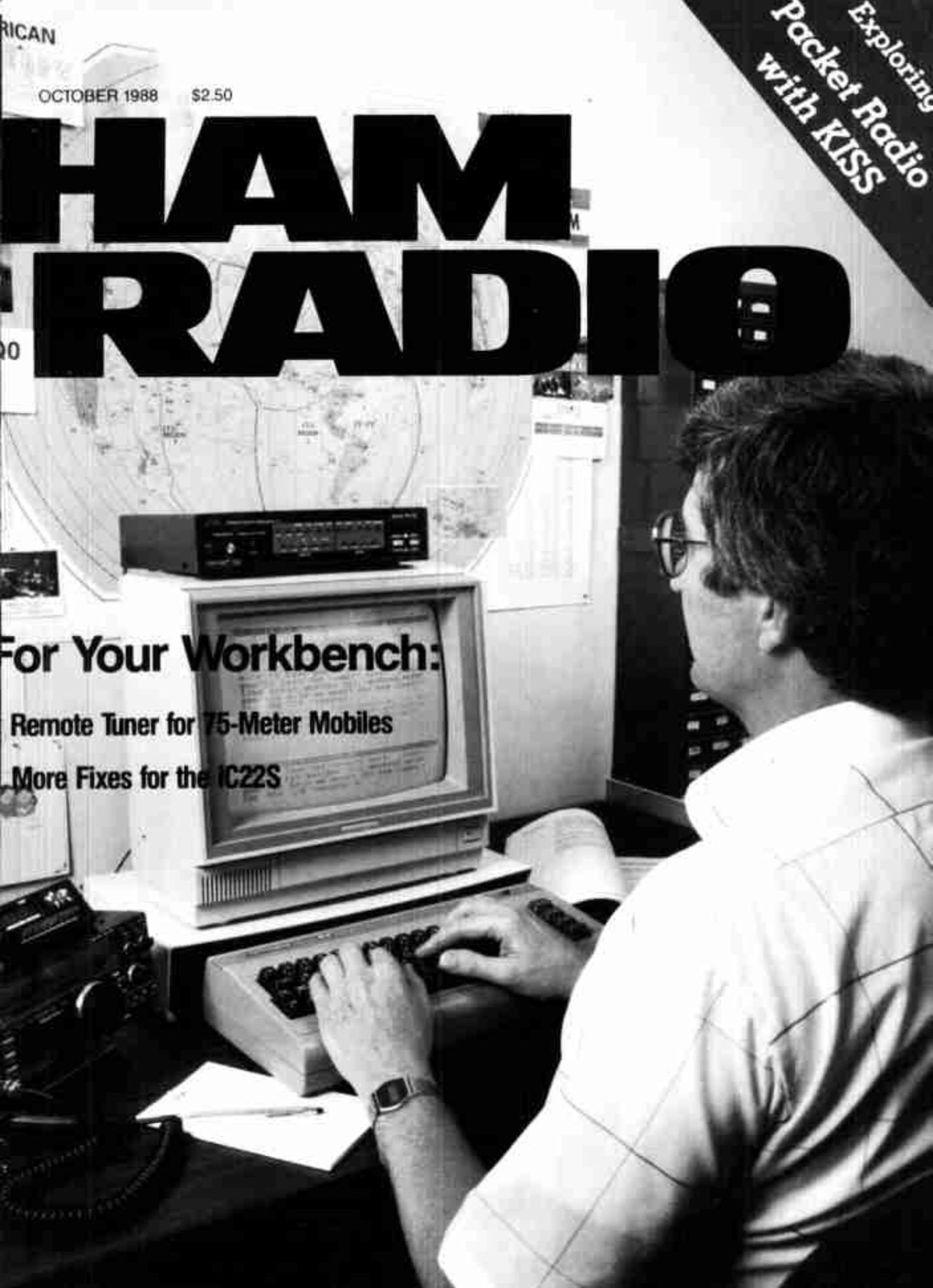
✓ 201

RICAN

OCTOBER 1988 $2.50

HAM RADIO

Exploring Packet Radio with KISS



For Your Workbench:

Remote Tuner for 75-Meter Mobiles

More Fixes for the IC22S

HAM RADIO

OCTOBER 1988

volume 21, number 10

T. H. Tenney, Jr., W1NLB
publisher
and editor-in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
production editor

Peggy Tenney, KA1ODG
copy editor

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Henry S. Gallup, KA1RYG
advertising sales manager

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Phil Alix, N1FPX
traffic manager

Maribeth Buchanan
HAM RADIO Bookstore

AEA
cover

HAM RADIO Magazine is published monthly by Communications Technology, Inc Greenville, New Hampshire 03048-0498
Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail), one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 101

Microfilm copies are available from Buckmaster Publishing Mineral, Virginia 23117

Cassette tapes of selected articles from *HAM RADIO* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1988 by Communications Technology, Inc. Title registered at U.S. Patent Office

Second-class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *HAM RADIO* Greenville, New Hampshire 03048-0498

FEATURES

9 Exploring Packet Radio with KISS
Michael Pechura, WA8BXN

17 Designing a Station for the Microwave Bands: Part Three
Glenn Elmore, N6GN

36 The Weekender: Remote Tuner for 75-Meter Mobiles
Joel Eschmann, K9MLD

38 Ham Radio Techniques: A Look at the Ground-plane Antenna
Bill Orr, W6SAI

47 Pathfinder Part Two
Ron Todd, K3FR

63 Efficiently Launch VHF/UHF Wave
Hal Silverman, W3HWC

65 The Weekender: A Code Practice Oscillator
John Pivnichny, N2DCH

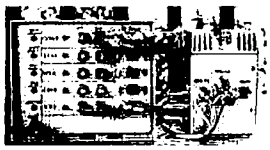
71 VHF/UHF World: IMD and Splatter
Joe Reisert, W1JR

85 Practically Speaking: Standing Waves: A Review
Joe Carr, K4IPV

91 More Fixes for the IC22S VHF Radio
Brian J. Henderson, VE6ZS

109 Pi Network Equations
Mason A. Logan, K4MT

113 Elmer's Notebook: Modems and RS-232
Thomas McMullen, W1SL



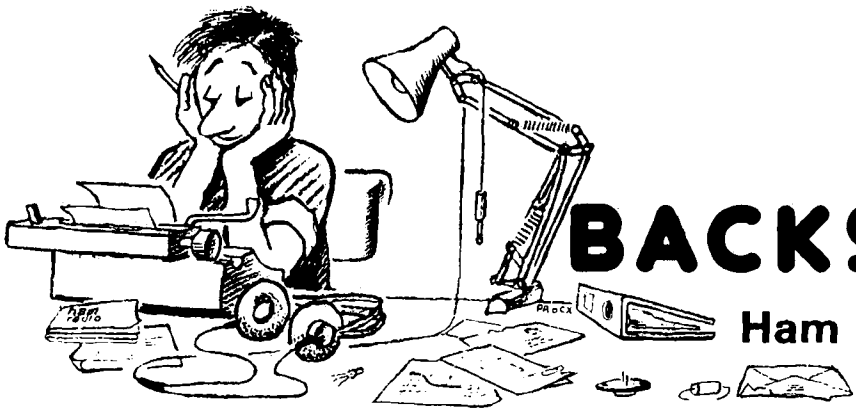
N6GN, Page 17



K9MLD, page 36
N2DCH, page 65

DEPARTMENTS

Backscatter	4	DX Forecaster	96
Comments	6	Ham Mart	100
New Products	41,42,102, 105,106	Flea Market	111
		Advertiser's Index	118
Ham Notebook	82	Reader Service	118



BACKSCATTER

Ham Bands Under Siege?

Over the years, a number FCC actions have created a tremendous amount of controversy in the Amateur field.

The latest bombshell is assured of being one of the most hotly contested ever. On August 4, the FCC decided to reallocate 220-222 MHz to the Land Mobile Service. The roots of this action are in a proposal made 18 months ago by the FCC Office of Engineering & Technololgy to "address a need to promote spectrum efficient technology and reduce overcrowding in the commercial services." During the formal comments period, thousands of negative responses were filed by hams, concerned citizens, the military and other government services. In addition, Congressional resolutions against the proposal were working their way through both the House (Resolution -317) and Senate (Resolution -127).

Then from out of the blue, six months after the formal closing date for comments, the United Parcel Service, filed comments in support of the FCC proposal. Even more remarkable was the FCC's acceptance of the UPS proposal — it was as if they were prepared *and* had been waiting for it. Is the FCC saying to us now that the dates they put on proposals are flexible at the Commissioner's whims? One must wonder what kind of anarchy rules the FCC or where the pressure is coming from...

What's even more scary is the thought that this could only be the opening battle in the possible war to take away all of our frequencies. Chod Harris, editor of "The DX Bulletin" editorialized in the August 2 issue that due to lack of operation on the 30-meter band, it will only be a matter of time before another service proposes to take it away from us. There is the possible threat to 160 meters from the broadcasting industry. If they can move the band up to 1700 KHz, why not 1800 KHz, or even higher still? And what about 450 MHz? We've already lost part of the band on the Canadian border. What's to prevent a proposal to take all of the band from us based upon this action.

Now is the time to act. There are three ways you can help. First, write your congressional representatives and senators expressing support for the concurrent resolutions now before them. Second, the ARRL is urging all Hams to support a proposed amendment (see below) to legislation to freeze the FCC's rules as of August 3. Send your letters, telexes, QSLs in support of the amendment to Congressmen Markey and Dingle and Senators Inouye and Hollings at the addresses below. Finally, stay informed of all developments in this and all other actions that could seriously affect our hobby!

There's no turning back now! What couldn't happen has. If we do not stand up to this threat, who knows what we'll lose next.

Craig Clark, N1ACH

Radio Spectrum Allocation Amendment Spec. The Commission shall enforce the regulations, rules, and policies in effect as of August 3, 1988, as they relate to the Amateur Radio Service in the 220-225MHz frequency band as defined in 47 CFR Section 2.106 (Table of Frequency Allocations).

U.S. HOUSE

Rep. John D. Dingel (D-MI)
Room 2221 RHOB
Washington, D.C. 20515
Tel: (202) 225-4071
Attn: John Orlando

Rep. Edward J. Markey (D-MA)
Chairman of Telecommunications and Finance Subcommittee
Room 316, House Annex II
Washington, C.C. 20515
Tel. (202) 226-2424
Attn: Gerry Salemme

U.S. SENATE

Sen. Ernest F. Hollings (D-SC)
Chairman Commerce, Science and Transportation
Room SD-508
Washington, D.C. 20510
Tel: (202) 224-0427
Attn: Ralph B. Everett

Sen. Daniel K. Inouye (D-HI)
Chairman of Communications Subcommittee
Room SH-227
Washington, D.C. 20510
Tel. (202) 224-9340
Attn: Tom Cohen



COMMENTS

Remembering a great scientist

Dear HR

KR6A in his article on Hertzian Waves omitted the findings of a very great scientist. I speak here of Nikola Tesla who proved that radio waves travel as do sound waves, *i.e.* longitudinally.

He also proved that Hertzian Waves are transverse waves and that these exist in the gases of the antenna both transmitting and receiving.

From this it can be seen that Hertzian Waves do not travel through space.

Arnold King, Jr. W2ZT, McAllen, Texas 78504

Neutral grounding

Dear HR:

Even though I'm very busy preparing for a vacation I feel compelled to write in reference to the excellent letter in the July issue (1988) of Ham Radio by I.L. McNally, K6WX and his subject of neutral grounding. The subject is especially timely, as that same issue carries an article by Bill Orr on page 60 and gives reference to grounding the neutral at an amplifier.

There are several additional reasons for grounding the "neutral" current carrying conductor *only* at the service entrance; these are addressed in the National Electrical Code. One of the main reasons for grounding one of the secondary wires of the step-down transformer which supplies electricity from the distribution system is for safety. Should the transformer insulation fail and the secondary not be grounded by some means, that fault could put a very high voltage (7,000 volts or more) on house wiring, as measured to ground. But precautions must also be taken when the neutral is grounded. It is sort of a case where one solution somewhat creates another problem if proper wiring practice is not followed. The problem is that should the conducting path somehow be broken between the neutral bus between the load the transformer, and a small neutral wire somewhere in the house (say 14 g. for instance) be grounded, all neutral current (which could be 100 or 200A depending on the "unbalance") will flow over that 14 g. wire (which is normally rated at about 15A current capacity for house wiring) and possibly cause a fire. Then, yet another problem can occur. When the 14 g. wire melts through, the neutral will no longer be at ground potential depending on the load across the hot to neutral, and any equipment that is connected to what was once a neutral at something close to ground potential is now possibly somewhere near 120 v.a.c. creating a real shock hazard!

There is an important difference between a *grounding* conductor and a *current-carrying grounded neutral* conductor. In addition to the reasons listed above, any ground fault breaker or receptacle I have ever worked with will trip if its neutral is grounded anywhere downstream of the ground fault protector. Don't bypass ground fault protection or disable it in order *to* ground a neutral somewhere. *Don't ground neutrals* for important safety reasons, not to mention ground loops, hum, and rfi problems. Proper use of 240 v.a.c. and 120 v.a.c. in a device which requires both voltages demands a four-wire system of two hot wires, the neutral grounded current-carrying conductor, and the grounding conductor; all the excuses ("it's my wiring, I'll do with it what I want; I don't believe in the wiring code; the government isn't going to tell me what to do,") notwithstanding, including what you see in radio handbooks. I also must politely and gently chastise Bill Orr for seemingly promoting this incorrect and dangerous practice. I suggest the proper wiring methods be addressed, with schematics, in one of his very next articles.

Richard M. Lorenzen, WA0AKG, Lincoln, Nebraska 68504

Need for basics

Dear HR

As a long-time subscriber to your magazine, let me congratulate you on your announced intentions of changing the editorial policy with regard to the type of articles we can expect to find in *HAM RADIO*.

The quality of your articles in the past has been excellent for the better educated electronic engineer, but I find too many of the average hams are not able to cope with the math and other explanations. They look at the article and lay the magazine down without reading this type of article. Pretty soon they find so little use for the magazine, they drop the subscription. I have had considerable contact with many hams in this area and that is what they have given me to understand.

Many times hams have told me they got along fine building things with tubes but they got behind on semiconductors and now they are lost. It seems to me there is a need for articles stressing basic understanding of how semiconductors work and articles on building with simple standard transistors and ICs, not the latest sophisticated ICs that are not available to most hams.

I hope your change of policy works!

Robert R. Hall, W0CRO, Minneapolis, Minnesota 55406

EXPLORING PACKET RADIO WITH KISS

By Michael Pechura, WA8BXN, CIS Department, Cleveland State University, E. 24th at Euclid Avenue, Cleveland, Ohio 44115

Learn more about what you're sending and how it works

Packet radio is one of the few areas left in Amateur Radio where you can do some experimentation with only a modest outlay for equipment. Those who already have a packet radio station have most of the equipment they need.

Unfortunately, most people on packet are "appliance" operators, not experimenters. I know it's easy to get on packet radio, but what do you do after connecting to all the locals on packet, reading all the messages on the bulletin boards, and watching all the Netrom "garbage" go by? Is there anything more you can do to find out about the real workings of packet, to experiment with this form of digital communication, and learn more about the interaction of your computer with packet radio? There certainly is!

There have been many articles explaining the data formats and the concept of networks, but it's also important to see packets in detail as they are being used. Fortunately, many of the Terminal Node Controller (TNC) manufacturers have begun to include a new feature in their TNCs, making experimentation and learning the details of packet easier. The feature is KISS mode (Keep It Simple Stupid!) access to the TNC. Provided to support a networking method called TCP/IP, KISS lets your computer do all of the decoding and construction of basic packet frames.

You can use KISS to really *see* everything in the packets being heard, and then to generate any type of packets you want. Now you can use your computer to implement any new features you might like to put in your TNC.

There are some problems, however. With KISS you can transmit your own packets, but you shouldn't write anything to the TNC when you're in KISS mode until you fully understand the process. If you don't and send out packets with errors, they will probably be ignored by the TNCs receiving them. They also might be illegal, particularly if there isn't a valid identification transmission. Transmission of valid packets isn't really very hard, but it's important to listen and learn first.

To understand what happens in KISS mode you'll need to review what the TNC does when it's not in KISS. The TNC contains a microcomputer for the initial input of commands. When the connect command is given, the TNC transmits the right kind of packet to initiate a connection. If the connect request is successful, the lines you typed are made into packets to be transmitted. The packets received are sent to the computer to be displayed as lines of text. The TNC handles all the details of the AX.25 protocol, like sequence numbers and error handling. These details aren't important if you don't intend to experiment with packet radio.

When a TNC is running in KISS mode it receives a string of characters that make up the complete packet to be transmitted from the computer. When the TNC receives a packet it sends the whole thing to the computer, and the computer then decides what to do with it. The TNC sends all packets it hears to the computer and the computer must retransmit the lost packets. There is no command mode; the TNC acts much like a dumb modem. However, when the TNC is sent a packet to transmit, it is responsible for generating the proper error detection bits at the end of the packet. It also waits until the channel is clear before transmitting and keys the push-to-talk line. When the TNC hears a packet on the radio, it checks the error detection bits and ignores the packet if it contains an error.

The details of KISS mode

Because KISS mode is simple, the description of its interface is short. Once in KISS mode, strings of bytes are sent by the TNC to the computer for each packet it receives. The beginning and end of these strings are marked by bytes of **C0** hex. These strings are called frames and they all have this basic pattern:

C0 YY XX XX XX XX XX XX ... XX XX **C0**

where **YY** is the type of KISS frame (normally 0 in frames from the TNC) and the **XX**'s represent bytes that form a packet. These bytes might be header information or data being transmitted in the packet. The first byte after **C0** is a command byte identifying the kind of frame. This byte will be 0 for data received from the TNC for single port TNCs.

A minor problem arises when a packet contains a byte that is hex **C0**. You must not confuse this **C0** with the one that marks the end of the packet, so the TNC will never send a byte that is within a packet with the bit pattern **C0**. If such a byte does exist it will send two bytes, **DB** and **DC**, indicating that a byte of **C0** is actually in the packet. This solution for the **C0** problem gives rise to another one — how to have the bit pattern **DB** in a packet. This is solved by never sending a byte that is part of a packet as **DB**. In its place two bytes are sent, **DB** followed by **DD**. The situation above is referred to as the transparency problem, or how to tell data from delimiters. (It's much like the programming question of how to put a quote mark in a character string that is enclosed in quotes.)

Frames sent to the TNC by the computer also use this same format, with some different values for the command byte. You must follow the rules carefully for solving the transparency problem given above. For the present, concentrate on what you can learn and do by just listening in KISS mode; don't worry about transmission details yet.

Programs for your computer

It isn't terribly difficult to write programs for KISS mode. They can be written in most languages. My favorite program language is C. BASIC is a much more widely available language, however, and the programs given here will use it.

Because the bytes from the TNC in KISS mode arrive at the computer at times determined by the TNC, the program running in the computer must be ready to receive them. Interrupt driven serial I/O is *required*.

Two popular computers for Amateur Radio are the C-64 and the IBM PC, and its clones. Because some of the syntax for BASIC is quite different for these two computers, I've provided listings for both machines. You can adapt the programs for your own machine. Interrupt driven serial I/O is standard in BASIC for the C-64 and IBM PC. Make sure this is also the case for any other computer you might use.

Just about any TNC that supports KISS mode can be used with these programs. The difference between one TNC and the next is the set of commands used to get the TNC into KISS mode. The TNC used to prepare these programs is a Kantronics KPC-2, which can be used with either true RS-232 compatible computers or the TTL levels used by the C-64. When using another TNC, refer to its operating manual for the necessary commands.

The simplest (and sometimes most useful) program that can be written for KISS mode is one that displays, in hex, the bytes the computer receives from the TNC. This program lets you see everything there is in a frame, including the **C0** bytes at the beginning and end.

The program for the C-64 is listed below:

```
10 PRINT CHR$(147) + CHR$(5);:POKE 53280,0:POKE
   53281,0
20 OPEN 2,2,3,CHR$(7): GET# 2,A$
30 PRINT# 2,"KISS ON" + CHR$(13) + "RESET"
40 H$ = "0123456789ABCDEF"
50 GOSUB 100: A = ASC(A$)
60 PRINT MID$(H$,A/16 + 1,1) + MID$(H$,(A AND
   15) + 1,1) + "  ";
70 GOTO 50
100 IF PEEK(667) = PEEK(668) THEN 100
110 GET# 2,A$: IF A$ = "" THEN A$ = CHR$(0)
120 RETURN
```

Go through this program line by line noting the subtleties. This will help if you want to convert it to another version of BASIC. Line 10 uses a print statement to clear the screen with CHR$(147) and set the character color to white with CHR$(5). There are single keystrokes that could be enclosed in double quote marks for these, but since they usually don't reproduce well in listings the equivalent CHR$ forms are used instead. The two POKE statements set the background and border colors to black. While these colors work best on my color monitor, you may change them if you prefer.

Line 20 opens the serial port as device 2. The 7 in the CHR$(7) specifies 600 baud operation. The default of 8 data bits with no parity matches the format of data from the TNC when in KISS mode. Because 600 baud operation has been specified (the C-64 may not operate reliably at higher speeds), the TNC must also be set for 600 baud operation to the computer (ABAUD 600 for the KPC-2 TNC). The GET# 2,AS$ turns on the interrupt system. Any byte actually read at this time is discarded.

Line 30 sends commands to the TNC as if they had been typed during normal use of the TNC. "KISS ON" tells the TNC to turn on KISS mode. This actually happens when the TNC is reset. Using CHR$(13) is the same as pressing the return key after typing KISS ON.

Next, "RESET" is sent to the TNC. Because there is no semicolon at the end of this print statement, BASIC also sends a return character to the TNC along with a line feed which the TNC ignores.

Line 40 initializes a string to the hexadecimal digits used later to display the bytes in hex.

Line 50 calls the input routine that gets one byte from the TNC as the character variable A$. The decimal equivalent is also put in the variable A.

Line 60 prints the byte received in hexadecimal form by using the high and low order 4 bits of the bytes, each of which selects a character from the string H$. This method is used to print a byte in hexadecimal as C-64 BASIC doesn't include such a function. After the two hexadecimal characters are printed, two blank characters are printed. A single blank could be used between the hexadecimal values instead, giving more values on a screen, but two blanks keep the values lined up in columns. You may change this as you wish. After a byte in hexadecimal has been printed, Line 70 goes back to get the next byte from the TNC.

Line 100 begins the byte input routine. It's written as a subroutine for convenience in later programs, but could be included where called in line 50 of this program because it is only called from one place.

Besides getting a byte from the TNC, this input routine overcomes two problems found in the use of GET# alone. The first is that GET# always returns immediately whether a character is available or not. Locations 667 and 668 are addresses of bytes in the input buffer of the interrupt routine. When these addresses are the same, no characters have been received. The loop of line 100 waits for a character to be received. The second problem with GET# is that it gives a null string, both when no byte has been received and when the byte received is all 0 bits.

Since a byte of all 0 bits is valid when dealing with KISS mode, line 110 replaces a null character string with a byte of all 0 bits. You can do this because at line 110 a byte has been received. Line 120 simply returns to line 50 with the received byte in A$.

Output from this program might look like the following:

```
C0 00 92 88 40 40 40 40 00 AE
82 70 84 B0 9C 01 03 F0 4D 53
59 53 20 69 6E 20 4B 49 52 54
4C 41 4E 44 2C 20 4F 48 20 20
57 41 38 42 58 4E 2D 31 33 2F
42 20 20 57 41 38 42 58 4E 2D
31 2F 4E 20 0D C0 C0 00 9A C2
D2 D8 40 40 00 AE 82 70 84 B0
9C 01 03 F0 4D 61 69 6C 20 66
6F 72 3A 20 41 4C 4C 20 C0
```

Here there are two frames, each beginning and ending with **C0**. Because the C-64 uses a 40-column display, there will be only 10 bytes per line. To study the output, run the program during periods of low activity. Pressing the RUN STOP key will halt the program and let you study what's on the screen. (By the way, don't attempt to modify the program to send the screen output to the printer. Interrupts on the C-64 are turned off when it's printing and this prevents bytes from being received properly from the TNC.)

The output may include a few initial bytes that aren't in KISS mode. This is simply output from the TNC before it was switched into KISS mode. Turn the TNC off to get it out of KISS mode.

The IBM PC version of the program is structured like the C-64 version:

```
10 CLS
20 OPEN "COM1:600,N,8,1,CS,DS,CD" AS 2
30 PRINT #2,"KISS ON" + CHR$(13) + "RESET" +
   CHR$(13);
40 H$ = "0123456789ABCDEF"
50 GOSUB 100: A = ASC(A$)
60 PRINT MID$(H$,A/16 + 1,1) + MID$(H$,(A AND
   15) + 1,1) + "  ";
70 GOTO 50
100 A$ = INPUT$(1,2)
110 RETURN
```

Each line performs the same functions it did in the earlier program. Although BASIC on the IBM PC does provide a function to convert to hexadecimal, it gives only one hex character for values between 0 and F. Because this would cause variations in the spacing of the output, the same method used to convert to hexadecimal in the C-64 program is used again.

The input subroutine that begins at line 100 is simpler in this version of the program, since the INPUT$ function found in BASIC on the IBM PC does all you need it to do. The output from this program looks much like the output from the C-64 version, except that now there will be 20 hex values per line. It's also possible to substitute LPRINT for PRINT in line 60 to send the output to the printer.

Suggested modifications

Now that you can see all the bytes in the frames and have verified that the format is indeed as described, what next? You can get a copy of the format descriptions of the various packet types, and see how the bytes displayed fit these formats by decoding them by hand. You can also make modifications to let this program help decode the packets. Adding everything needed to fully decode packets results in a considerably longer program (about a page long). There are a few simple program changes that will allow you to see some of the content of the packets more easily.

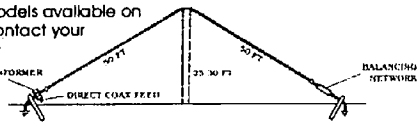
Try substituting the following statements in the program. They will work in either version.

CONTINUOUS COVERAGE ANTENNAS
FOR COMMERCIAL & AMATEUR SERVICE

Model AC 1.8-30 — 1.8 to 30 MHz

- SWR Max 2:1, 1.4:1 average from 1.8 to 30 MHz
- Can be installed in approximately 80 ft. space
- Ideal for commercial services for multi frequency operation without the need for antenna tuners or additional antennas
- Handles 1 KW, 2 KW PEP ICAS
- Higher power models available on special order. Contact your dealer or factory

$175.00 SHIPPING & HANDLING ADD $4.00

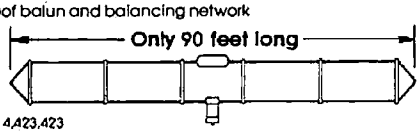


U.S. Patent No. 4,511,898

Model AC 3.5-30 — 3.5 to 30 MHz

- SWR less than 2:1 from 3.5 to 30 MHz
- Complete assembled. Balun terminated with standard SO-239 connector
- Power capability 1 KW - 2 KW PEP ICAS. Higher power model is available on special order.
- Designed for 50 ohm feedline
- Weather proof balun and balancing network

$184.50 SHIPPING & HANDLING ADD $4.00



U.S. Patent No. 4,423,423

ALL OUR PRODUCTS MADE IN USA

B·W BARKER & WILLIAMSON

Quality Communication Products Since 1932
At your Distributors... Write or Call:
10 Canal Street, Bristol, PA 19007
(215) 788-5581

AMATEUR TELEVISION

SMILE! YOU'RE ON TV



Only $299

Designed and built in the USA Value + Quality from over 25years in ATV...W6ORG

With our all in one box TC70-1 70cm ATV Transceiver you can easily transmit and receive live action color and sound video just like broadcast TV. Use any home TV camera or VCR by plugging the composite video and audio into the front VHS 10 pin or rear phono jacks. Add 70cm antenna, coax, 13.8 Vdc and TV set and you are on the air...it's that easy!

TC70-1 has >1 watt p.e.p. with one xtal on 439.25, 434.0 or 426.25 MHz, runs on 12-14 Vdc @ .5A, and hot GaAsfet downconverter tunes whole 420-450 MHz band down to ch3. Shielded cabinet only 7x7x2.5". Transmitters sold only to licensed amateurs, for legal purposes, verified in the latest Callbook or with copy of license sent with order.

Call or write now tor our complete ATV catalog including downconverters, transceivers, linear amps, and antennas for the 70, 33, & 23cm bands.

(818) 447-4565 m-f 8am-5:30pm pst. Visa, MC, COD

P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006

Tom (W6ORG)
Maryann (WB6YSS)


```
60 IF A>=32 AND A<=126 THEN PRINT A$;:
GOTO 50
65 PRINT ".";
```

These statements print as *characters* the bytes that are received from the TNC. Those that are normally unprintable will be displayed as dots. Quite a few funny-looking characters may be displayed, but you'll recognize some strings of characters that make sense. You should be able to recognize the text portion of the packets that would be seen if the TNC was being used normally.

Here's one output you might get while running on IBM PC:

```
....@@@@...p.....MSYS in KIRTLAND, OH
WA8BXN-13/B WA8BXN-1/N.....@@...p.....Mail
for: ALL .
```

Note that the spacing on the screen will be somewhat different. This output corresponds to the same bytes shown in the hexadecimal output examples above.

Another change that you can make follows. Again it will work with either version of the program.

```
60 A=INT(A/2):A$=CHR$(A):IF A>=32 AND
A<=126 THEN PRINT A$;:GOTO 50
65 PRINT ".";
```

These changes will produce character output once again, but it will look different. You should be able to recognize the callsign portion of the packets (to and from callsigns and digipeaters, if any). The callsigns are shifted left 1 bit position in the packet, so the program makes them printable by shifting the bytes right 1 bit position (by dividing by 2). Sample output might look like this:

```
`.ID      .WA8BXN..x&),).47.%$)*&` ''..'$.. +
.!,`....!.. + .!`...`..`
`.Mail    .WA8BXN..x&046.379.. &&.`
```

Again, the output on the screen may be spaced slightly differently from what appears here in print. These are the same bytes, just looked at a different way.

Conclusions

These programs and their modifications should help you start using KISS mode to explore the details of packet radio. Anyone familiar with BASIC should be able to understand and modify the programs further.

Many improvements are possible; the possibilities are endless. Modifications can be made to monitor channel usage (Are the beacons really using up that much channel capacity?) or decode nonstandard packet types (What does all that "garbage" in Netrom packets really mean?). Here's a golden opportunity to experiment and put your computer and packet gear to good use when you're bored with just reading the mail.

Article A **HAM RADIO**

DESIGNING 'A' STATION FOR THE MICROWAVE BANDS: PART THREE

By Glenn Elmore, N6GN, 550 Wiliowside Road, Santa Rosa, California 95401

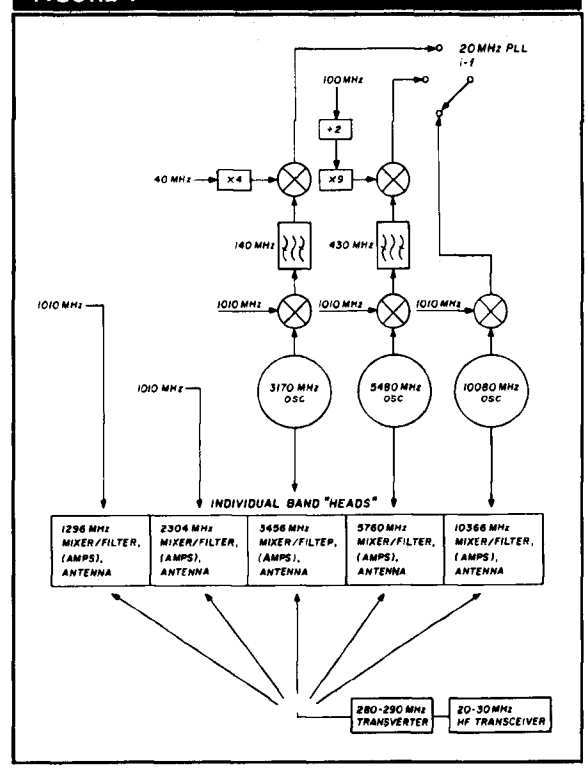
1296 MHz-10 GHz in one compact station

Part 1 discussed some of the advantages microwaves can have over lower frequency signals for point-to-point communications. I presented a generalized approach using phaselock techniques which allows access to the calling frequency on each Amateur microwave band and supports linear signal conversion: SSB, CW, and other narrowband modes. You can obtain a spectrally pure and precise local oscillator signal for any of the Amateur microwave bands with a single pc board design in several separate loops, including only those components needed for a particular loop. Table 1 in Part 1 showed that you can obtain SSB operation on all the Amateur bands from 1296-24192 MHz using a 1010-MHz reference oscillator to downconvert and phaselock an available microwave oscillator, along with an appropriate i-f and microwave signal mixer.

I've demonstrated this approach with the description of a 10368-MHz SSB station. But, its broader applications shouldn't be lost in the specifics of the 10-GHz example; the technique can be used with all of the microwave bands. You can achieve 1296-MHz, 2304-MHz, and 10368-MHz operation by adding the signal mixer/filters (a harmonic mixer with 1010-MHz LO drive can be used on 2304) once circuits for the 100-MHz quartz oscillator, 1010-MHz coaxial oscillator, and 10-GHz oscillator are functioning. Operation is possible at 3456 MHz and 5760 MHz with the addition of an oscillator/downconverter and signal mixer/filter. You can add more microwave amplification for transmit and receive on a band-by-band basis.

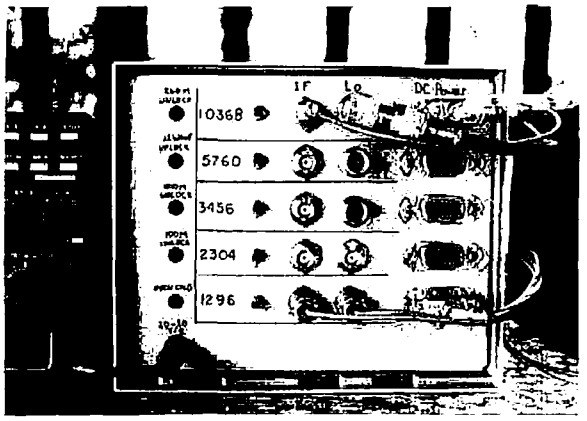
Although Table 1, part 1 showed how to get on all

FIGURE 1



Once the 10368-MHz station using the 280-290 MHz signal i-f is built, 1296 and 2304 MHz are immediately available. The two microwave bands in between, 3466 and 5760 MHz, may be included by adding suitable VCOs at 3170 and 5480 MHz, along with harmonic mixers and circuitry to convert their PLL i-f to 20 MHz.

PHOTO A



Five-band operation is easily obtained using this phaselocked transverter.

the bands using the 1010-MHz signal, some of the alternatives result in inverted tuning (high side LO) and a 432-MHz i-f. If you include a frequency conversion after the PLL harmonic downconverter, normal tuning and exclusive use of the 280-290 MHz i-f is feasible. **Figure 1** shows the block diagram for a five-band LO. You don't need to construct additional phaselock circuitry; you can use the 10-GHz phaselocking circuits for multiple bands as long as you provide similar oscillator tuning sensitivities. To change bands, simply switch the power and PLL i-f to the desired oscillator/downconverter. **Photo A** shows a phaselocked transverter with provision for five bands, having little more circuit complexity or size than previous single-band units.

You can get immediate 10368-MHz SSB operation if you have a 148-MHz transceiver and proper reference frequency to give a 10220-MHz LO. However, you'll need a 280-290 MHz i-f to take advantage of the potential multiband operation. Part 3 shows the circuits for the 260-MHz phaselocked oscillator, and the amplifier and switching circuits used to convert a 20-30 MHz Amateur transceiver to and from the 280-290 MHz intermediate frequency required for multiband microwave operation. I'll also show the two-stage GaAsFET amplifier used for the 10368 station.

260-MHz local oscillator

I'll begin the description of 280-290 MHz transverter with the 260-MHz phaselocked LO. It would have been easy to use a conventional approach because this transverter isn't very different from a low power (zero dBm) 220-MHz one. I could have used an 86.666-MHz crystal oscillator followed by a tripler and appropriate filtering, but I didn't want to compromise the frequency accuracy of the microwave station with a less accurate unlocked i-f transverter LO. You can maintain overall frequency control by the 10-MHz frequency standard (or the 100-MHz crystal if it's operated unlocked) by using another common phaselock board and building a VCO at 260 MHz.

Obtain the 40-MHz PLL i-f by mixing the VCO output with the third harmonic of a 100-MHz reference signal. A standard double-balanced mixer (like an SRA-1) works well because it's effectively an odd harmonic mixer. A harmonic downconverter produces an appropriate i-f for locking. The oscillator uses a junction FET. (I make no claim that it's the best that can be done.) It isn't necessary to have superlative spectral purity in this application because, unlike the 1010-MHz case, no higher harmonics are used for further phaselocking; simplicity of design and ease of construction win. Even so, the spectrum of this LO when locked is good, and doesn't contribute significantly to microwave signal phase noise. The 260-MHz bandpass filters and buffer stages are present only for isolation and to keep any reference frequency derivatives from showing up on the 260-MHz signal. If you take care to separate the PLL i-f signals from the main 260-MHz output, any spurious signals are at least 75-dB down. **Photo B** shows the oscillator.

You'll need a 40-MHz reference frequency to lock this oscillator. A 20-MHz ECL reference signal drives a bipolar transistor frequency doubler, which drives an extra ECL line receiver. These circuits are located on the previously constructed 100-MHz reference board.

As with the 1010-MHz downconverter circuit, a 100-MHz bandpass filter and amplifier keeps any lower frequency signals on the ECL output from passing straight into the PLL i-f amplifiers through the harmonic mixer.

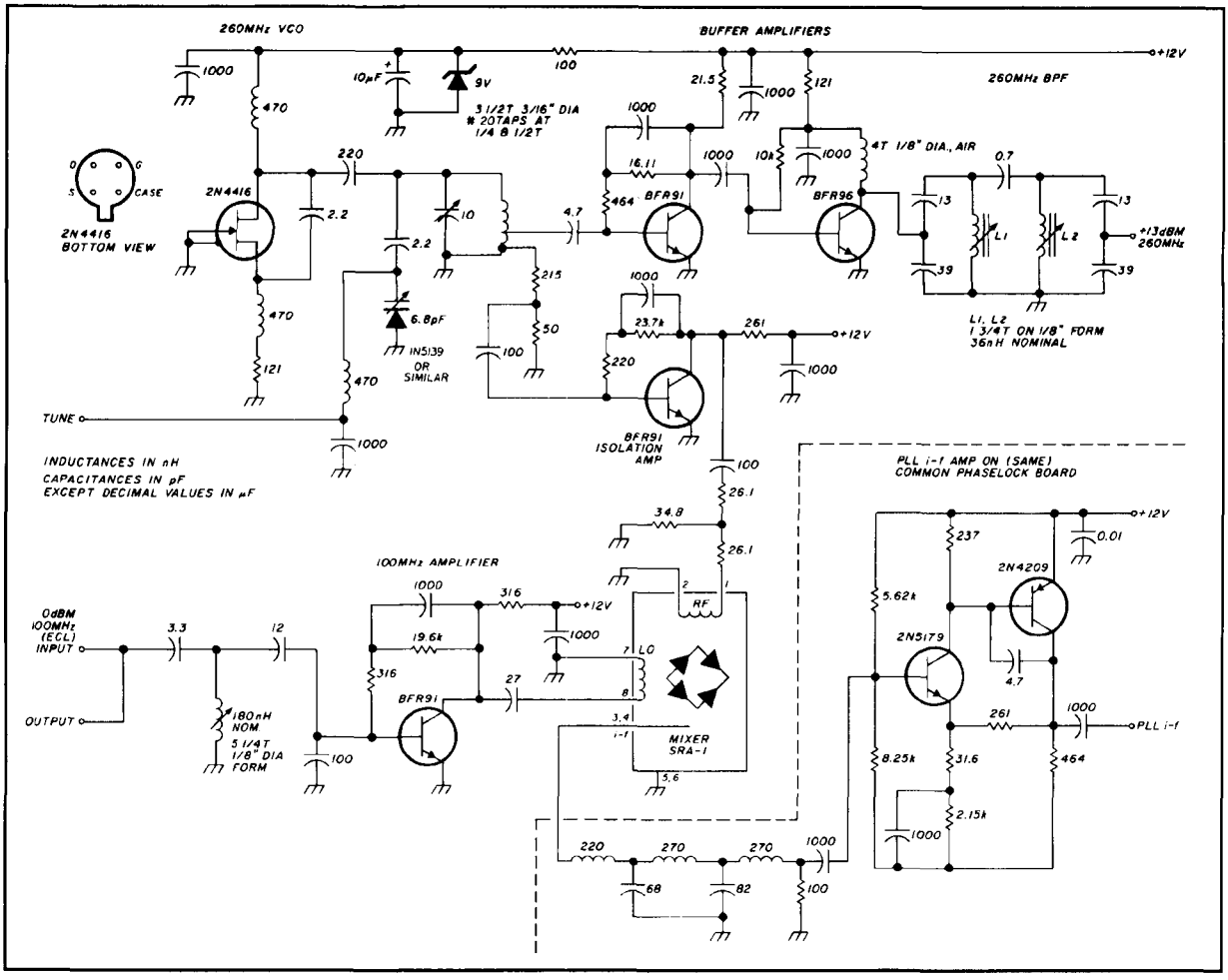
All of the locking circuits are identical to the ones used before. **Table 2**, part 1 shows component values for the loop filter. Component values for the lowpass

PHOTO B



This oscillator is used in obtaining the 260-MHz LO.

FIGURE 2



The 260-MHz phaselocked LO for the 280-290 MHz transverter uses a simple junction FET oscillator and two different amplifiers — one for the signal mixer and the other for driving the harmonic downconverter.

Discover
CAROLINA WINDOM

80-10 M
Use transmatch
132' overall
Matching XFMR
Line Isolator
Vert Radiator
Coax fed
Assembled
$69.96

High performance
Proven results
$70 Beam?

Your
Passport
To a world
Of new ideas
And exceptional
HF wire antennas

Rugged new baluns
Full range of HF, UHF,
mobile antennas, ducks, wire,
coax, parts, line, accessories.
SEE WHAT WE'RE DOING NOW!
Contact Jim, W4THU
- free discount catalog
Send $1 for catalog by 1st Class mail.
Box 6159, Portsmouth, VA 23703
(Dealer inquiries welcome)

The RADIO WORKS

804-484-0140

CAROLINA WINDOM
SEE THE REVIEW IN JUNE '88 WORLD RADIO MAGAZINE.
Enthusiastic users say it's the best wire antenna. Outperforms wire antennas previously used. Knock-your-socks-off performance on 80 - 10. A $70 beam?
If you hear one, you'll want one.
Made with pride by The RADIO WORKS in VA/USA

✓ 110

THE RF CONNECTION
"SPECIALIST IN RF CONNECTORS AND COAX"

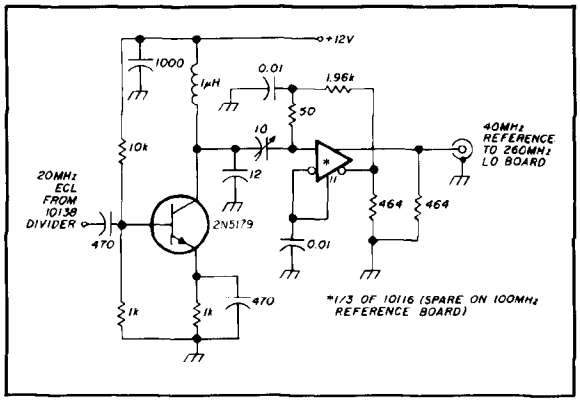
Part No.	Description	Price
321-11064-3	BNC 2 PST 28 volt coaxial relay, Amphenol Insertion loss: 0 to 0.75GHz, 0.10dB Power rating: 0 to 0.5GHz, 100 watts CW, 2 kw peak Isolation: 0.1 GHz/45db, 0.2 GHz/ 40db, 0.4 GHz/35db	$25 used tested
83-822	PL-259 Teflon, Amphenol	1.50
PL-259/ST	UHF Male Silver Teflon, USA	1.50
UG-21D/U	N Male RG-8, 213, 214, Amphenol	2.95
UG-21B/U	N Male RG-8, 213, 214, Kings	4.00
9913/PIN	N Male Pin for 9913, 9086, 8214 fits UG-21D/U & UG-21B/U N's	1.50
UG-21D/9913	N Male for RG-8 with 9913 Pin	3.95
UG-21B/9913	N Male for RG-8 with 9913 Pin	4.75
UG-146/U	N Male to SO-239, Teflon USA	5.00
UG-83/U	Female to SO-239, Teflon USA	5.00

"THIS LIST REPRESENTS ONLY A FRACTION OF OUR HUGE INVENTORY"

THE R.F. CONNECTION
213 North Frederick Ave. #11
Gaithersburg, MD 20877
(301) 840-5477 ✓ 111
VISA/MASTERCARD: Add 4%
Prices Do Not Include Shipping

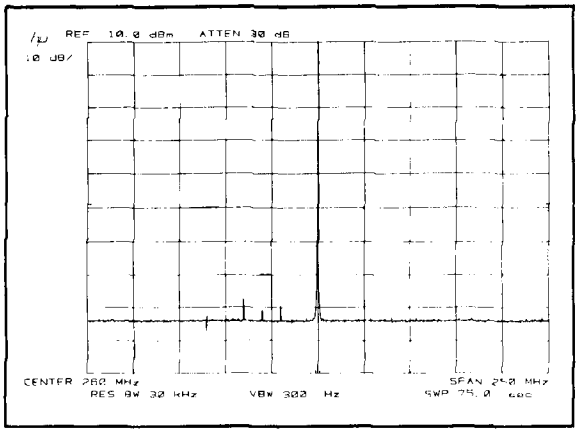
Electronic Repair Center
Servicing
Amateur **Commercial Radio**
The most complete repair facility on the East Coast.
Large parts inventory and factory authorized warranty service for Kenwood, Icom and Yaesu.
SEND US YOUR PROBLEMS
Servicing "Hams" for 30 years, no rig too old or new for us.
HAMTRONICS, INC.
4033 Brownsville Road
Trevose, Pa. 19047
215-357-1400

FIGURE 3



The 260-MHz locking circuitry requires a 40-MHz reference frequency. This is obtained by doubling the existing 20-MHz ECL signal in a transistor and restoring ECL logic levels with an extra 10116 line receiver.

FIGURE 4



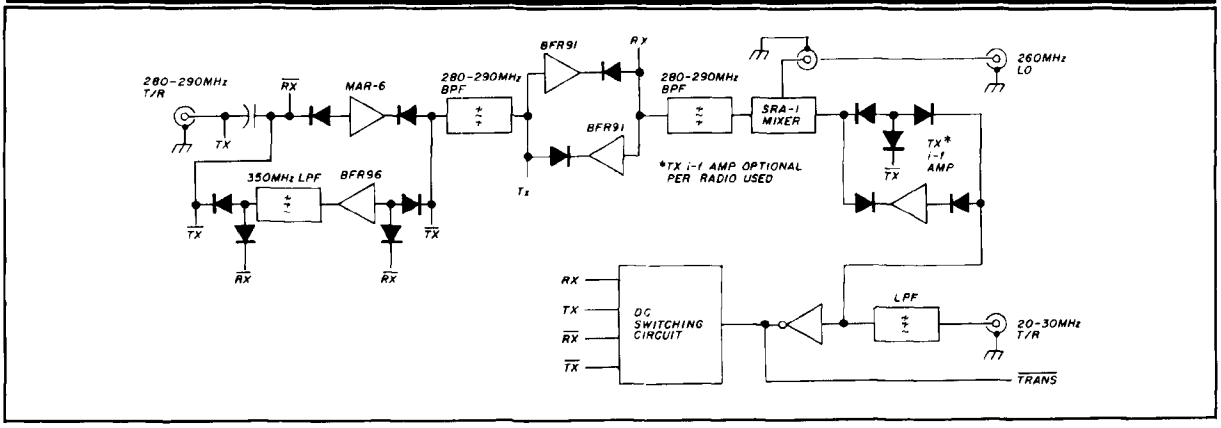
The spectrum resulting from phaselocking the 260-MHz VCO is quite clean. Both spurious signals and noise are smell compared to the carrier.

filter after the harmonic mixer are modified to pass the 40-MHz PLL i-f. Use the jumpers marked "-" on the common phaselock board. **Figure 2** shows the schematic of the oscillator/amplifier and PLL i-f. The 40-MHz reference circuit is shown in **fig. 3**. **Figure 4** shows the spectrum of the phaselocked 260-MHz oscillator.

280-290 MHz transverter mixer, amplifiers, and switching

Figure 5 shows a block diagram for the 280-290 MHz transverter, **fig. 6** is the schematic diagram and **fig. 7** shows the dc biasing scheme. I tried to use easy to find parts and a design requiring a minimum of test equipment for final tuning. Broadband amplifiers are used in the hf and VHF portions of the transverter. Frequency selection is performed with a lowpass filter at hf and two 2-resonator filters for VHF. It's desirable to have a moderately high-gain low noise input stage to set the overall noise figure on receive at VHF. I chose an MMIC since Avantek/Mini Circuits MMICs seem to be easy to find at reasonable prices. I tried a MAR-8 (Avantek MSA-0885) first, and got good performance after taking care with grounding and construction techniques. To increase stability, I used a 30-ohm resistor in series with its output. The MAR-8 doesn't have heavy internal feedback to control its gain (and SWR), and provides a noise figure in the area of 3 dB. But this device is only conditionally stable and has *lots* of bandwidth — several GHz of it. You must control feedback paths as well as source and load impedances over a very large frequency range in order

FIGURE 5



The transverter uses a conventional double balanced mixer, broadband amplifiers, and appropriate filtering to convert the 20-30 MHz hf transceiver to 280-290 MHz. Transmit/receive switching is performed by PIN diodes and a dc switching circuit, which provides bias for the appropriate stages. Transmit output power of about 0 dBm (1 milliwatt) and receive conversion gain of about 8 dB is provided.

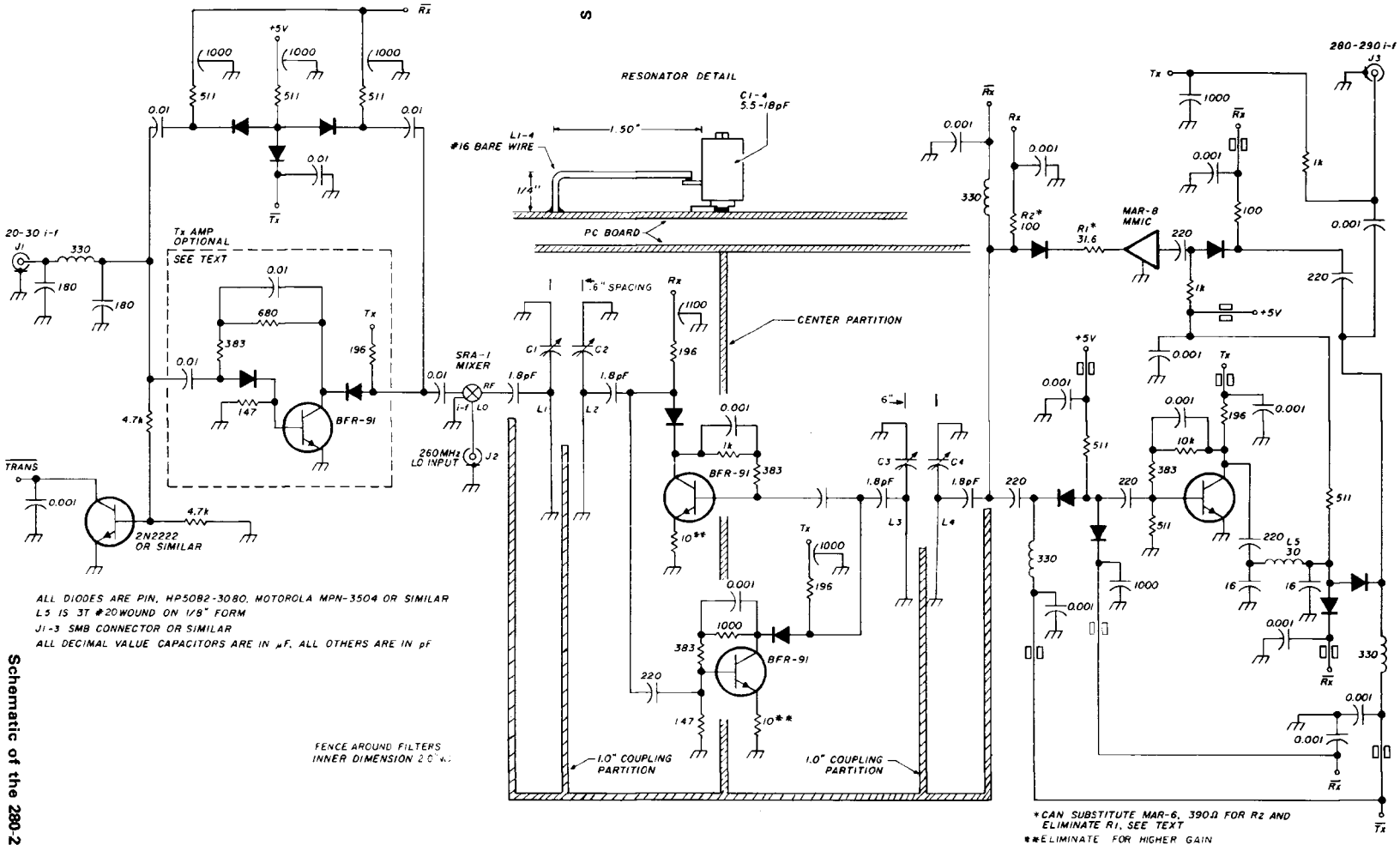
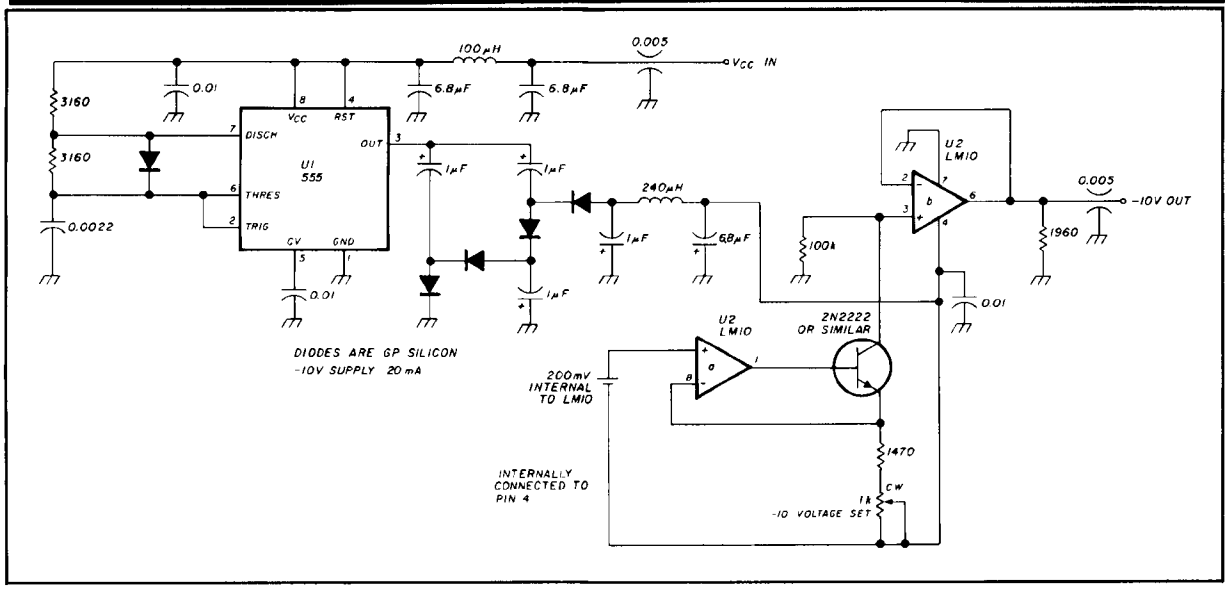


FIGURE 6

Schematic of the 280-290 MHz transverter.

FIGURE 7

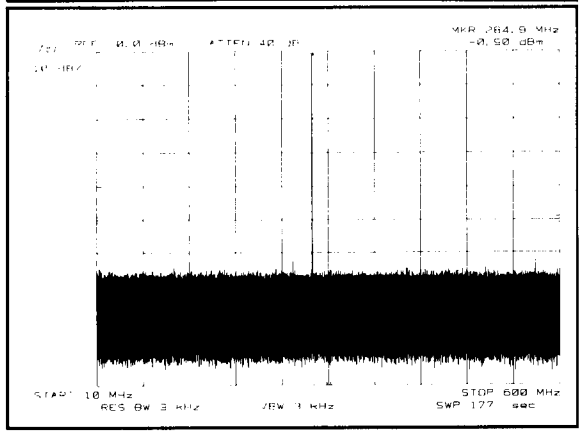


DC biasing scheme for the 280-290 MHz transverter.

to keep it from oscillating. I replaced the MAR-8 with a MAR-6 (Avantek MSA-0685) and got a better match. The MAR-6 is unconditionally stable, with better input and output match. This is important because the 280-MHz filter, if not the microwave signal mixer, requires low SWR terminations for minimum ripple and insertion loss. However, the MAR-6 has lower gain at 280 MHz than the "resistor stabilized" MAR-8. This results in a 0-3 dB conversion gain for the transverter with the MAR-6, in contrast to about 8 dB with the MAR-8. The extra gain with the MAR-8 helps the noise figure by overcoming the 280-MHz filter losses and interstage amplifier noise figure. Measured overall, transverter noise figure is about 3 dB with the MAR-8 and 5 dB with the MAR-6. If you use signal frequency amplifiers, and not just a "barefoot mixer", the lower conversion gain and higher noise figure of the MAR-6 may not be a concern. If you choose a MAR-6, change the collector bias resistor to 390 ohms and remove the 30-ohm series resistor required for the MAR-8.

I use a BFR-96 on transmit, with the appropriate collector and feedback resistances, to provide a compromise of gain and match at 280-MHz. This stage only needs about zero-dBm output to drive the signal mixer (assuming microwave LO power in the +10 dBm vicinity). The interstage amplifiers used between the two filter portions ensure a good input and output match for the filters to work against. I could have used a 4-resonator filter without interstage amplifiers instead of twin 2-resonator sections, but I felt that tuneup without test equipment would be harder. The mixer should probably look into a broadband 50-ohm

FIGURE 8



The spectrum of this transverter on transmit shows unwanted signals suppressed by more than 60 dB. At full output of about 0 dBm only the 260-MHz LO feedthrough and the second harmonic of the signal are visible.

termination instead of a filter for best signal performance and lowest conversion loss, but once again simplicity won out. Unwanted LO leakage and image signals should be at least 60-dB below maximum output. Figure 8 shows the output spectrum of the transverter on transmit.

For transmitting, special circuit versatility is necessary in the transverter's hf circuit. This is because there's no standard transvert-mode output power level for modern multiband Amateur transceivers. Some manufacturers provide outputs of 1-100 milliwatts, while others are almost 30 dB less. I used another BFR-

91 stage which can be "programmed" for various gains. The values on the schematic are right for my ICOM IC-751; it puts out about −15-dBm maximum on SSB/CW transmit in transverter mode. If your exciter has more drive than this, you may need to eliminate the stage or put in a resistive attenuator. As shown, the transverter puts out about 0 to +3 dBm on voice peaks of my IC-751. The PIN diode switch lets the full mixer output reach the receiver during receive. If your station receiver has particularly low gain, you could include another amplifier stage here. This shouldn't be necessary for most applications using microwave preamplifiers. Even with a "barefoot mixer", the transverter as shown exhibits 8-10 dB conversion gain on receive. This should make up for most of the conversion loss from a microwave mixer.

The 280-290 MHz filter was designed to be easy to use and construct. The inductor is an extremely simple and reproducible wire-over-ground plane. I was concerned that most of the coupling between resonators might be between the tuning capacitors themselves, and too dependent upon *construction* technique and layout. However, construction with a number of different types of tuning capacitors produced similar results.

Other possibilities

Because this filter is the only block (besides the LO) which controls frequency, you should be able to obtain transverters for 144, 220, and 432 MHz by changing the filter elements. This might be attractive at 220 MHz as a frequency doubler driven by the 100-MHz reference could provide the LO. A 120-MHz phaselocked VCO with a 100-MHz downconverter reference and 20-MHz PLL i-f would work for 144 MHz. The downconverter could be a conventional mixer. A fourth-harmonic anti-parallel diode mixer with 100-MHz reference and 10-MHz PLL i-f would suffice to lock a 410-MHz VCO for 430-440 MHz operation.

Switching

Because of the number of possible bands, I devised a standard transmit/receive interface — each with its own microwave head (mixer, filter, amplifiers and T/R switch). You should get full microwave output power on transmit, with zero dBm of i-f power. I chose to use Vcc on the rf signal line to indicate transmit; this allows "daisy-chaining" control. When the hf transceiver signals transmit by pulling the NOT-transmit line low or putting Vcc on its signal line, the 280-MHz transverter amplifiers are turned on in the transmit direction, and Vcc is passed to its rf port. As a result, the connected microwave circuitry goes into transmit. For this reason, hardware for each microwave band can be located at, or near, the antenna, minimizing feedline losses. Any band can now be selected from the operating position by connecting the i-f from the transverter. The local oscillator signals incur power losses on the way to the heads. But, excess LO power is generally available and microwave signal mixer conversion efficiencies aren't much influenced by moderate reduction of LO drive, as long as LO power is several dB greater than the maximum i-f power of zero dBm. Even at 10 GHz where losses are greatest, you can probably locate the microwave head and antenna at least 10-20 feet from the operating position if you use good quality coax. All that's required between the operating position and the head for each band is the connection of two coaxial cables, i-f and LO, and one dc power cable (where needed). This allows for continuing enhancements in the microwave heads, improved noise figure, and higher power amplifiers — without the necessity of impacting the local oscillator sections. Feedhorn/head combinations can be quickly exchanged using a single antenna during a band-change, if you provide a mount for a standard box at *the feedpoint of a reflector antenna.*

Because the 280-MHz transverter is electronically switched, transmit turnaround time should be that of the hf transceiver alone — unless there is a slower mechanical T/R switch in the microwave head. Microwave AMTOR should work with this arrangement.

Although Vcc may be indicated as 12 volts on some of the previous schematics, I actually run the entire station from the output of a low-dropout 3-terminal adjustable regulator set to *11 volts.* This tends to keep gains and amplitudes stable, and allows operation on nearly discharged 12-volt automotive batteries. A separate 5-volt regulator provides the power for the ECL logic.

Transverter construction

I built the 260-MHz VCO in the space on the common phaselock board allocated for the 100-MHz oscillator and divider circuits. Because the board was made with lots of component-side ground plane, I soldered right to the ground plane or mounted components by their leads. Lead length was kept to a minimum. To do this, use 1/8th or 1/16th-watt resistors, and other physically small components. (I find that a large pair of tweezers is a great construction aid.) The lower impedance of the broadband amplifier stages tends to make them less sensitive to parasitic capacitances, which can be layout and lead-length dependent. Be particularly careful to connect directly the ground end of the capacitors and the coils on the 260-MHz bandpass filter. A clean, phaselocked +10 dBm 260-MHz signal results if the phaselock downconverter and 260-MHz amplifier/filter portions are kept at a reasonable distance from one another.

The 280-290 MHz circuits are built using a similar technique. But, for this board I started with a bare piece of approximately 3″ × 6″ double-clad 1/16th-inch thick Fiberglas™ pc board material (G-10). I cut 0.100″ square pads and soldered all rf components to the board instead of building much of the circuit above the ground plane, as I did with the 260-MHz oscillator. Cutting out pads is easier than it sounds. You can prepare the entire board in one sitting with a microscope. Use a small hobby knife to cut away the copper around the pads. You'll get an isolated pad by scoring through the copper, then shifting the blade and cutting a vee or trough into the top of the board around a 0.100″ square. As with the 260-MHz oscillator, the small component and pad size force you to control and limit the lead length. All ground connections should first be drilled completely through the board in the MMIC area. Then solder the component or lead to be grounded on both the top and bottom, to reduce the possibility of coupling inside the board. I drilled holes to clear the packages of the MMIC and the output BFR-96 transistor. This let me solder the emitter leads to the topside ground without excess lead length. Drill a hole for these leads and solder them to the top and bottom ground planes.

Be sure to follow the dimensions when making the filter inductors and mounting the tuning capacitors. The spacing between resonators in each pair is important to set filter coupling and provide the correct 8-10 MHz bandwidth. After cutting the pads and building the interstage amplifiers, solder the pc board "fence" on both sides around the filter assembly. The hf circuitry isn't critical, but I used the same "mini-pad" technique. It's desirable to connect the 260-MHz LO signal to the mixer with a piece of small coax. Try to use coax with an O.D. of 1/8″ or smaller. Use minimum length on both the mixer and connector ends to avoid radiating 260-MHz energy around the filter, where it may be amplified during transmit by the output BFR-96. Such radiation could cause the unwanted LO feedthrough to be suppressed by less than 60 dB. This radiation would be in-band and small on all of the microwave bands, but it's unnecessary.

I built the dc switching circuits on a piece of breadboard, which I mounted at one end of the transverter. I suggest using a 0.125-A fuse or foldback current limiting in the dc supply until you've finished troubleshooting and tune-up because the PNP transistors will self-destruct if their cases, or the RX or TX supply lines are inadvertently shorted when they are turned on. In normal operation, all these transistors are used as switches and have very little power dissipated. I brought out the NOT-Transmit line to allow keying when an hf transceiver providing Vcc on the signal line during transmit is unavailable. This point may also be monitored to tell if the hf transceiver is successful in causing the microwave station to go into transmit mode.

260-MHz LO tune-up

Finish the 260-MHz LO first; you'll use it to make the 280-290 MHz circuits work. Check your wiring and measure the current to the oscillator and each amplifier stage individually. As with the other loops, the phaselock portion, from the bipolar i-f amplifier onwards, can be checked by substituting one of the previously completed loops. A moderately sensitive detector of 40-MHz energy is desirable to tune the downconverter. An oscilloscope or a 40-MHz receiver should work. If you have neither, tune the oscillator to 271 MHz by listening to the PLL i-f at 29 MHz with the station receiver, to the PLL i-f at 29 MHz and tuning the variable capacitor slowly through its range. Do this with 6 volts applied to the tuning input. Verify that the signal heard tunes with the correct sense, and that you aren't overloading the receiver. Once you hear a signal which tunes correctly, peak it by adjusting the 100-MHz bandpass filter. To verify that the 40-MHz reference signal is present, use the diode detector from part 2, an oscilloscope, or other detector. To maximize it, peak the bipolar frequency doubler's collector tuning. Once the reference and PLL i-f inputs on the ECL phase comparator are at the correct level, the loop should lock when the VCO is (re)tuned to near 260 MHz. If you have trouble getting a sufficient level on the PLL i-f, temporarily bypass the attenuators on the input and output of the isolation amplifier to increase signal levels. It may be useful to count the VCO and keep track of operation during tune-up if a VHF frequency counter is available. Once the oscillator locks correctly with both isolation amplifier attenuators connected, peak the 260-MHz output by tuning L1 and L2 on the 260-MHz bandpass filter. You should now have a clean and accurate 260-MHz LO.

280-290 MHz tune-up

After completing rf circuit construction and rechecking the wiring, apply Vcc to each of the active stages with the switching circuitry disconnected. Measure and verify proper collector or emitter current. Verify that the TX, RX lines, and their complements alternate appropriately between nearly Vcc and ground as the TRANS line is alternately shorted to ground and allowed to float.

Once individual stage biases are correct and the switching circuits are functioning, complete the transverter construction by wiring the switched lines to the rf circuits. The transverter is probably best tuned on receive by using a local signal source in the 280-290 MHz range. The second harmonic of a 2-meter trans-

ceiver may be used, or the tenth of a 10-meter transmitter. Hook up the 260-MHz LO and the station receiver to the transverter. When you identify a suitable test signal, couple it to the bandpass filter nearest the interstage amplifiers on the MMIC side (280-MHz signal connector side). Tune the pair of resonators on the mixer side for maximum response. Next, couple the signal at the MMIC output side of the filter assembly and peak the other two resonators for maximum. The transverter should now be roughly tuned and operate on both receive and transmit. You can perform fine tuning to flatten the response over the full 10-MHz range by peaking one of the resonators in each pair on a 281-MHz signal and the other on a 289-MHz signal. If a 1290-1300 MHz transceiver is available, generate these i-f signals by connecting the 1010-MHz oscillator to a double-balanced mixer filter and completing the 1296-MHz station. The Mini-Circuits SBL-1X or TFM-2 mixers are only rated to 1 GHz for full specifications, but still perform reasonably well at 1296 MHz. If you use this method, you can tune up the transverter on either transmit or receive.

10-GHz amplifier

This two-stage amplifier was the next logical step in station improvement. Low noise amplification ahead of the mixer is necessary to reduce the overall receiver noise figure on receive. Without it the noise figure is approximately: $NF_{rx} = NF_{if} + CE_{mix}$ (+ 3 dB).
Where:
NF_{rx} = receiver noise figure in dB
NF_{if} = 288-MHz i-f receiver noise figure in dB
CE_{mix} = conversion loss of the microwave signal mixer

Even with an amplifier you get the additional 3 dB because, unless an image reject signal mixer is used, the noise at the image frequency is converted to the i-f and degrades the overall noise figure. The system noise figure can be essentially that of the amplifier alone by providing sufficient gain ahead of a bandpass filter which passes only the signal frequency and not the image. On transmit it's desirable to have more power than the few hundred microwatts the mixer alone can achieve; gain is required to do this. Amplifier gain is worth more than low noise figure because it overcomes other hardware noise figure problems on receive, and directly adds to output power on transmit. This can mean 2-dB of station improvement for every extra dB of amplifier gain. For these reasons, the amplifier was designed to have a compromise of good noise figure and maximum gain.

Design considerations

Neither low noise or high gain are as easy to achieve at 10 GHz as at lower frequencies. Gallium Arsenide field-effect transistors are currently the most readily available and suitable devices. Recent volume production of 4-GHz TVRO equipment has helped reduce the price and improve the performance of these parts. Gain elements aren't the only problem — losses in all circuit components whether lumped (like chip capacitors), or distributed (like microstrip transmission lines), must be kept to a minimum. Another significant problem (though not as noticeable at lower frequencies) is radiation loss. Wires, lines, and connections are no longer small in terms of the signal wavelength. Unless you take care to avoid it, a circuit can look more like an antenna than an amplifier. Building a circuit on a 2-1/2″ long circuit board at 10.368 GHz is comparable to building one on a full-size football field at 40 meters. Packaging circuits at these frequencies can be a challenge since cavities and resonances resulting from mechanical dimensions can cause unexpected results. Can you imagine connecting one end of a coupling capacitor to a goal post and the other to the 20-yard line?

I chose a NEC NE-710 for the input stage *and a NE-720* (or 2SK571) for the second stage. The 710 has lower noise and higher gain, while the 720 is relatively inexpensive. The 2SK571, which may only be available in Japan, is a bargain at about 500 Yen ($4 US) on the surplus market there. The 710 is matched and biased for near minimum noise figure while the 720 is matched for maximum gain.

About 6 of these amplifiers have been built. Consistency has been good with "tuned" gain between 15.5-17 dB and noise figure between 2.6-2.9 dB at 10368 MHz, for the group.

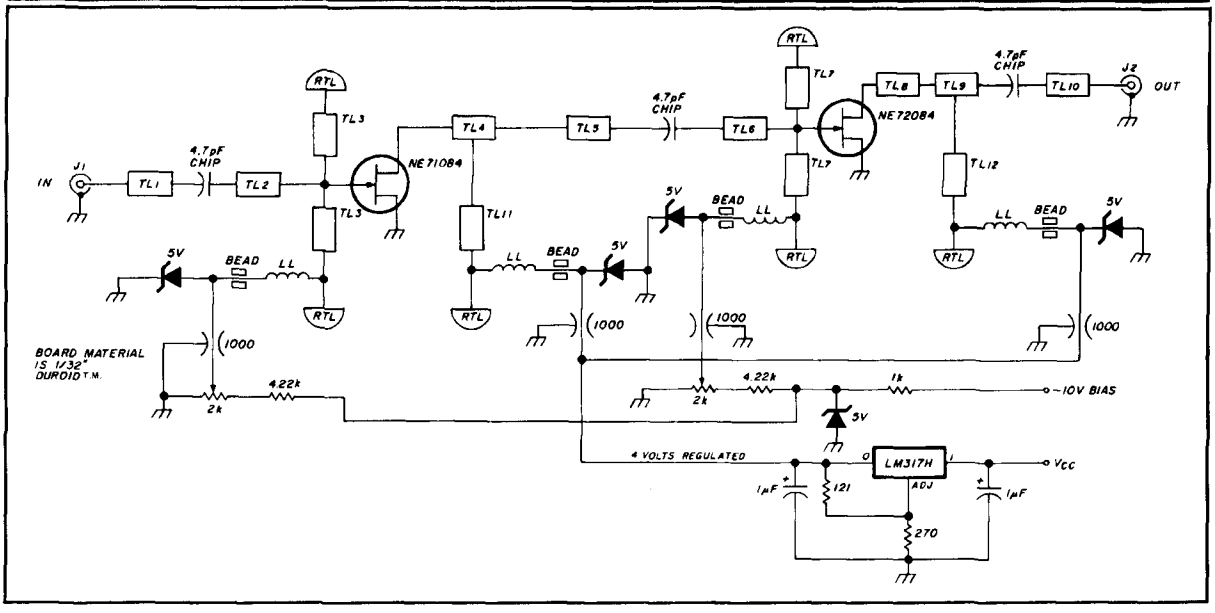
Construction

Unless suitable microwave test equipment is available, you should construct this amplifier after a stable narrowband 10368-MHz station is on the air. Because it needs to be made carefully, the experience gained in getting the downconverter and signal mixers operational should be useful in completing this amplifier.

The first circuits were made by "cutting and peeling" the microstrip traces from a piece of woven double-clad 1/32″ TFE (Telfon™-Fiberglass-Epoxy) board material. Rogers Corporation Duroid™ with random fibers was used for the final version because it's somewhat more uniform than woven board material. The woven board material can have a slightly different dielectric constant and shouldn't be substituted for the Duroid.

Use the highest-quality 4.7-pF coupling capacitors, especially in the input stage. About 0.5-dB improvement in noise figure was obtained by changing to high-Q capacitors from run-of-the-mill ones.

FIGURE 9



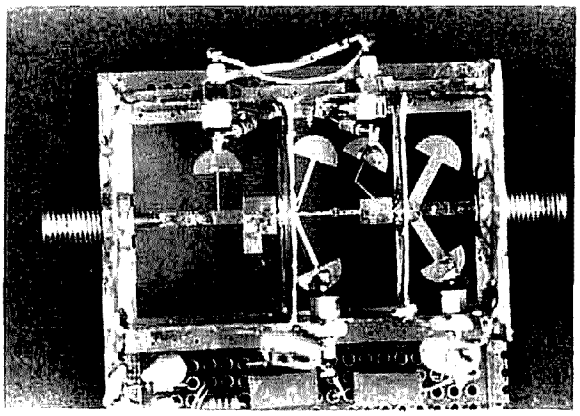
The two-stage 10-GHz amplifier uses a low noise NE710 in the input stage followed by a less expensive NE720 in the second stage.

Repeatable performance depends upon carefully controlled grounding and component mounting. This is particularly true relative to the transistors themselves. The transistor source leads are soldered to the circuit side ground trace, but front-to-back shorting wires right at the transistor package and plated-through grounding holes are present every 0.100" to maintain good grounding. Careful drilling and wire front-to-back connections should work if a plate-through pc board process isn't available. The "half-moon" radial transmission lines provide an easy way to match impedances and connect bias at the same time. The bias wire can be a resistor lead or small wire soldered right at the junction of the transmission line and the radial line. I put a ferrite bead, held in place by some silicone rubber, on each of these leads for insurance against lower frequency oscillations. The other end of these bias leads connects to its associated feedthrough capacitor. Position the beads away from the circuit board and near the feedthrough capacitors. A 5-volt zener is also connected to each of these capacitors inside the compartment for static and over-voltage protection.

Figure 9 shows the circuit diagram for the amplifier and bias supply. The bias supply (designed by Bob Dildine, W6SFH), provided negative gate bias for this amplifier and higher power transmit amplifiers during the 1987 10-GHz DX record attempts. The LM-10 allows good regulation without needing excess voltage and current to turn a zener diode on hard. Build this supply in a separate shielded enclosure. Use good quality bypass capacitors on the input and output lines to make sure no switching frequency signals get out and contaminate the rest of the station electronics.

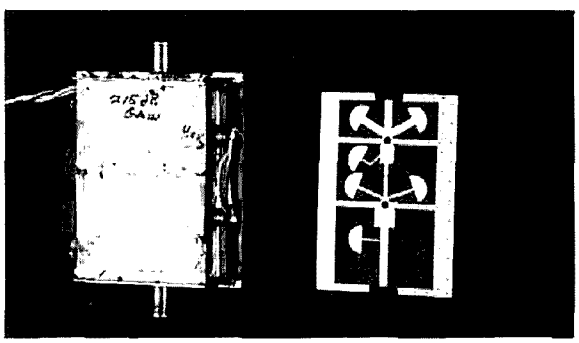
The SMA connectors flanges are soldered right to the board material on both top and ground plane sides. The notch in the board lets the face of the connector flange be flush with the edge of the board. The package is made from 0.030" copper sheeting cut to size, drilled for the feedthrough capacitors or connectors, and then soldered directly to the board as end and side walls. The package adds rigidity to the relatively flexible board material. Flexing can cause excessive strain and coupling capacitor breakage. Therefore, connector solder joints must be kept to a minimum. The SMA connectors are also soldered to the endwalls. Ground the gate and drain the circuits of both devices until you complete the assembly. Carefully assemble the transistors and coupling capacitors on the board with a microscope. Don't use a lot of solder. Take great care with these components; once they're soldered in place there is little chance of removing and reusing them. Interstage partitions can be made from 0.005-0.010" brass shim stock. Notch them just enough to allow clearance for the transistor package and source leads. Carefully solder them in place after the side walls (with feedthrough capacitors and protection diodes) are on. The partitions should protrude about 0.100" above the sidewalls so that the covers can be soldered on after you complete the tune-up. The covers for the interstage and output should have 20-40 ferrite beads glued to their undersides. This suppresses package

PHOTO C



The three compartments inside a completed amplifier are visible in this photograph. A shim "tuner" can be seen in the output stage (the largest compartment).

PHOTO D



This photograph shows the amplifier before and after the addition of the copper walls, connectors, and covers. Notches for the connector flanges and holes for the transistor packages are visible on the raw board.

resonances which could degrade performance. The input compartment doesn't have these "absorbers" because any additional losses can degrade noise figure. Krazy Glue™ or similar contact adhesives seem to work and stand the temperature when the covers are finally soldered in place. **Photos C** and **D** show the completed amplifier with covers removed.

Tune-up

You can do your tune up once the amplifier and bias circuits are completed, and either a station or other microwave test equipment is available. With the gate bias pots turned all the way down for zero-volts bias, gradually increase the drain supply voltage while watching the drain current. No more than 4.5-volts maximum should be necessary; going much beyond this will cause the protection zeners to start conducting. This zero-bias drain current, IDSS, varies from device to device; note the value for both stages. Next, slowly turn the bias pots to make the gates more nega-

KEEP IT INSIDE



- Frequency Range - 13 MHz to 30 MHz
- Power Limit - 1500 Watts P.E.P.
- Diameter - 39 inches
- Wind Survival - 70 + MPH
- Surface Area - < .89 Sq. Ft.
- Antenna Finish - Heat Shrink Tubing
- Coax Connector - PL-259
- Antenna Weight - 4 lbs
- Magnetic Design Maximum Efficiency
- 100% Copper One Piece Construction
- Military Spec Vacuum Variable Capacitor Rated at 35,000 Volts
- Hi-Q Harmonic Supression
- All Locations - Indoors or Outdoors
- Bi-Directional at 0-20 Degrees TOA
- Omni-Directional at 25-90 Degrees TOA
- High Signal to Noise Ratio
- Direct Feed 52 OHM Coax SWR < 1.5:1
- No Matching Unit, Pretuned Coax, Ground Screen or Radial System

WA2VMO 'A BELIEVER

WHEN YOU'RE TOLD YOU CAN'T — THE DMQ-5588 SAYS YOU CAN

OPERATION: Apply power to DMQ-5588 and adjust vacuum variable for lowest SWR.

INSTALLATION: DMQ-5588 inside ground floor apartment brick building 100W.

OX CONTACTS MADE BETWEEN 3/88 TO 5/88: SZ4 P43 PA0 TK9 DJ8 GW0 CP5 YS9 ZS6 J37 ZD8 HP9 WP4 IK4 HK6 GM4 I5 EA5 JH1 C6 HK6 IK2 GD4 PJ2 HP4 CE1 5Z4 5T5 KP4 UT4 SP3 CP3 F9 IK3 N91 UA6, UR2 UP1 YT2 UB5 IV3 EA5 TG9 GJ5 ON7 YU1 V01 DL6 J73 PY8 TI2 LZ1 PY5 OE4 GI0 G4 WP4 KL7

Become a Believer! For more information about this exciting new antenna, call or write DMQ today! Limited time intro offer: $349.50 + Shipping.

221 Slater Boulevard
Staten Island, NY 10305
(718) 979-3505

↙ 128

DMQ TECHNOLOGY

COMMANDER II VHF
LINEAR POWER AMPLIFIER



SPECIFICATIONS

Frequency Range – 144-148 MHz
Modes – USB, LSB, RTTY, FM
Power Requirements – 117/234VAC with 234VAC recommended
RF Drive Power – 10-15 Watts Nominal 25 Watts Maximum
RF Output – 15+ DB Gain or over 650 Watts
Input Impedance – 50 OHMS
Output Impedance – 50 OHMS Nominal
Antenna Load – 2:1 Maximum
Harmonic Suppression Down 60DB @ Rated Output
Intermodulation Distortion Down 30 DB Minimum
Weight – 56 lbs.
Cabinet Size – 14¾" x 14¾" x 6"
Tube – 3CX800A7 Ceramic/Metal Triode
Pressurized Chassis Forced Air Cooling

FEATURES

Reduced Ratio (6 to 1) on all Tuning Controls for Smooth and Easy Tuneup.
Front Panel Input Tuning Control Allowing a Higher Circuit "Q" for Excellent Linearity and a Very Low Input VSWR all Across the 2 Meter Band.
A Switched Multimeter for Monitoring Plate Voltage, Plate Current, and Grid Current.
External Coaxial Relay or Sequencer Needed for Transceiver Operation.
UPS Shippable.

MADE IN U.S.A. BY HAMS FOR HAMS
Direct from Manufacturer ↙ 121

$988.00 (Coaxial Relay Extra)

Ohio Residents Add Sales Tax. VISA and Mastercards accepted. Prices or specifications subject to change without notice.

COMMAND TECHNOLOGIES, INC.
1117 West High Street, Bryan, Ohio 43506 (419) 636-0443

FIGURE 10

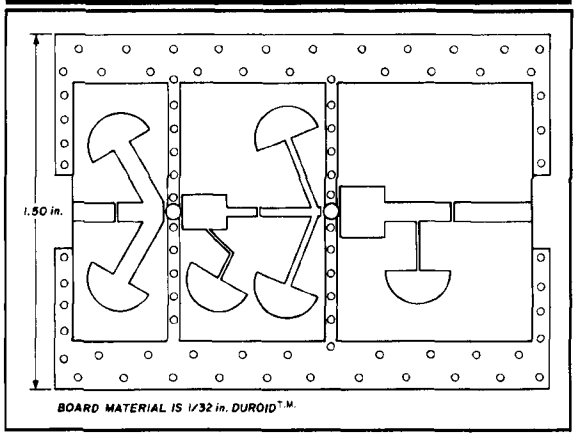


fig. 10A. The original pc board layout for the 10-GHz amplifier.

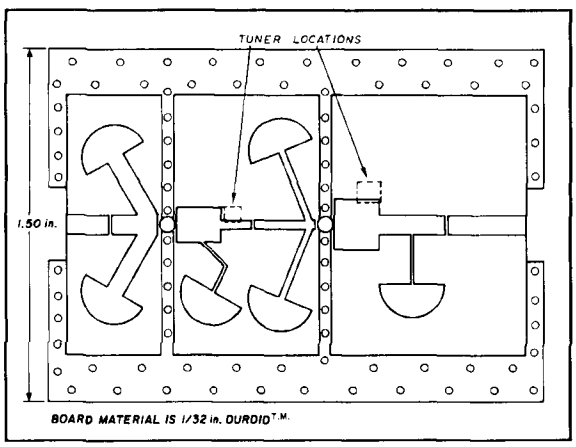
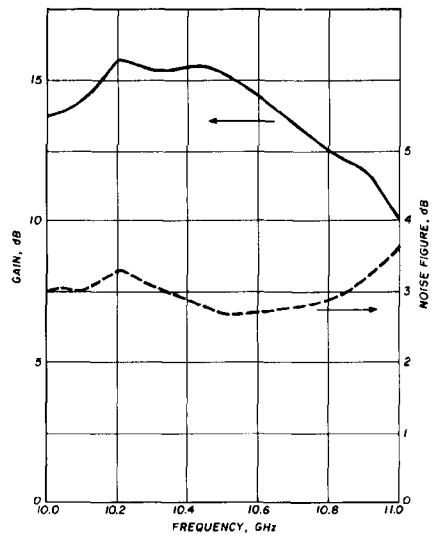


fig. 10B. The pc board layout showing approximate placement of the tuning shims. Note: The shims are glued to the board after finding the exact placement.

FIGURE 11



LL Resistor Lead

TL1 .083″W x .180″L	TL8 .220″W x .188″L
TL2 .083″W x .150″L	TL9 .083″W x .280″L
TL3 .078″W x .277″L	TL10 .083″W x .350″L
TL4 .15″W x .192″L	TL11 .01″W x .250″L (Can be .210″L)
TL5 .039″W x .134″L	TL12 .01″W x .210″L
TL6 .039″W x .220″L	RTL .145″ Radius half-circle
TL7 .029″W x .316″L	J1,2 Flanged SMA connector

The measured gain and noise figure of a typical amplifier. More than 15-dB gain and under 3-dB noise figure is readily available.

tive. The drain current should diminish as you do this. Set the 710-bias current to approximately 25 percent of its IDSS value and the 720 to about 50 percent. You can adjust these later for minimum system noise figure if you have access to measuring equipment, but you should be able to obtain near optimum performance with these settings.

An amplifier like this would require no tuning at lower frequencies. However, a little "tweaking" is useful at 10-GHz, as small variations in construction technique can affect performance. The need to adjust grew out of a mistake in the original design — that of not considering the extra circuit length provided by the gap over which the coupling capacitors are soldered. As a result of this error, untuned gain is about 13 dB. However, by adding small 0.05-0.100″ square, 0.002″ thick, brass shim stock tuners in the drain-matching circuits of the two stages, the amplifiers can be tuned for maximum gain. This also allows for small device-to-device variations in the transistors. **Figures 10A** and **B** show approximate positions for the tuning shims. Tune by first gluing one of the shim tuners at right angles to the end of a toothpick. Carefully use the toothpick to move the shim around, varying the amount it extends past the edge of the transmission line, as well as its location along the length of the line. While you do this, monitor a stable signal on 10368 MHz with the station-receiver S meter. Be sure to maintain contact with the drain-circuit line of the stage. Note the optimum position, turn the power off, ground all bias pins to the amplifier, and permanently solder an identical shim in the position noted. You don't need to perform input-stage tuning because the match provided is not far off, even with the capacitor-gap error. As you can see in **fig. 11**, minimum noise figure occurs slightly above the hamband calling frequency — but the difference is negligible.

The finished amplifier should exhibit less than 3-dB noise figure and at least 15-dB of gain. On transmit it should be able to deliver 30 milliwatts of linear power and about 50 milliwatts saturated. You may need to increase drain current to more than 50 percent of the IDSS value for maximum output.

Summary

Once the 3456-MHz and 5760-MHz local oscillators are completed, further station improvements will come in the form of better receiver preamps and more transmit power for all the bands. I anticipate that the rapid bandswitch and good system modularity will provide a good contest station, as well as one which can grow with available technology. If you want to build a similar station and try for an obscure record, QSOs on 16-18 different Amateur bands in 2-3 minutes should be possible with this equipment when augmented by a longwire antenna for the hf bands and standard VHF/UHF contest equipment. Another way to use this approach is for 900-MHz band operation. Use a 620-MHz VCO downconverted to a 20-MHz PLL i-f, with an anti-parallel diode mixer like the one used at 1010 MHz. This would give 900-910 MHz operation with the 280-290 MHz i-f.

I have ignored a couple of station components in this series. Transmit/receive switches are necessary in any station using signal frequency amplifiers. Many good units show up at flea markets and surplus stores. I also haven't provided construction information for a good ovenized frequency standard. Although the design presented here showed a 10-MHz standard, a good proportional oven around the unlocked 100-MHz oscillator may provide satisfactory results.

Thanks to Bob Dildine, W6SFH and Lynn Rhymes, WB7ABP for their interest, ideas, suggestions, and help with the station.

Some sources of microwave parts and information.

NEC transistors:
California Eastern Laboratories
3260 Jay Street
Santa Clara, California 95054
(408) 988-3500

Transistors, chip capacitors, mixers, PIN diodes, etc.:
Microwave Components of Michigan
11216 Cape Cod
Taylor, Michigan 48180
(313) 753-4581

An inexpensive (about $7) surplus 2-8 GHz double-balanced mixer (WJ-M62H) is available from:
HSC Electronic Supply
6819 Redwood Drive
Cotati, California 94928
(707) 792-2277

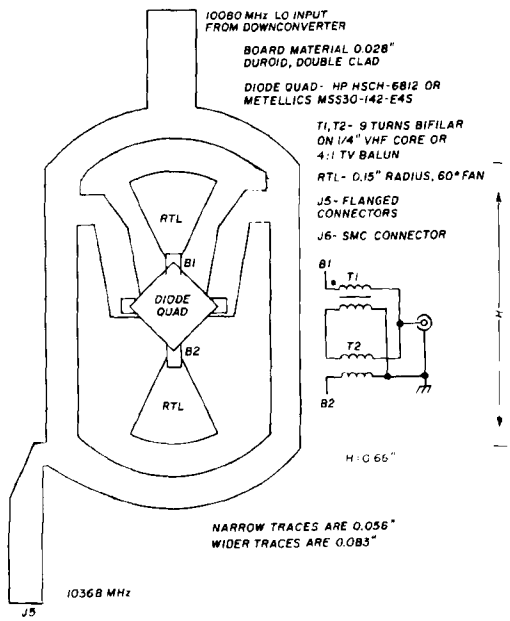
Article B **HAM RADIO**

short circuit

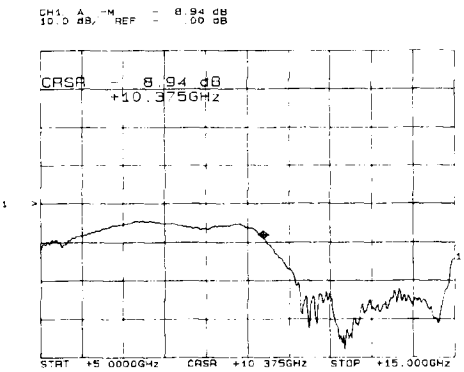
Part 2 of "Designing a Station for the Microwave Bands" in the June 1988 edition of *HAM RADIO* needs to be corrected at follows:

The schematic in **fig. 1** on page 20 incorrectly shows a connection between the 9-volt zener and the 7-nH inductor on the base of Q3. The drawing in **fig. 2** shows this correctly.

Although the schematic of the 10-GHz signal mixer in **fig. 11** is correct, the implementation shown in **figs. 9, 10,** and **19** have an error in the positions of the signal and the diode quad connections to the ring. Construction using the dimensions shown results in unnecessarily high conversion loss in the mixer at 10.4 GHz. A corrected **fig. 19** is shown here.



Sticky copper tape can be used to correct these errors if you've already made a board to the specifications of the original description. I apologize for any needless effort this may have caused.



As you can see from the plot of conversion loss versus frequency, this mixer is usable but not optimum on both the 5760 and 10368-MHz Amateur bands. Details of a version which is more optimum for 10368 MHz alone is available from the author for an SASE.

Ed.



THE WEEKENDER

REMOTE TUNER FOR 75 METER MOBILES

By Joel Eschmann, K9MLD, 6964 Meadowdale Drive, Hartford, Wisconsin 53027

This article is dedicated to those 75-meter mobile operators who are tired of getting out of their cars to retune their mobile whips every time they change frequency more then 25 kHz!

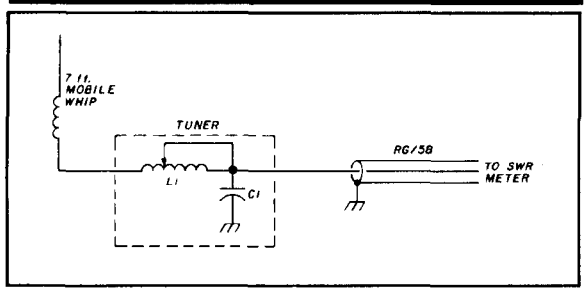
I'm an avid mobile operator on all the hf bands and I have no problem with the bandwidth of my antennas on 20/15/10 meters. But when it comes to 40 and 80 meters, I get frustrated hopping in and out of my car to tune my mobile whip when I QSY. No more! Here's a breakthrough that's so cheap and simple you'll want to use this tuner everywhere, as I have.

It occurred to me that I might use my existing mobile antenna tuned to 4 MHz and add inductance at the base to allow tuning lower in frequency. I wanted to do this across the whole phone band without leaving the front seat of my car.

The schematic in **fig. 1** shows that this is a very basic tuner concept found in all the text books. It was a problem finding an inexpensive motor-driven tuner that provided the correct inductance. While looking through many surplus catalogs, I came across a motor-driven Ribbon Roller Inductor at Fair Radio in Lima, Ohio. This silver-plated inductor turned out to be an excellent choice. Its gear train drives a rotary switch that can be used as a limit switch to stop the motor when the inductor gets to the end of its travel.

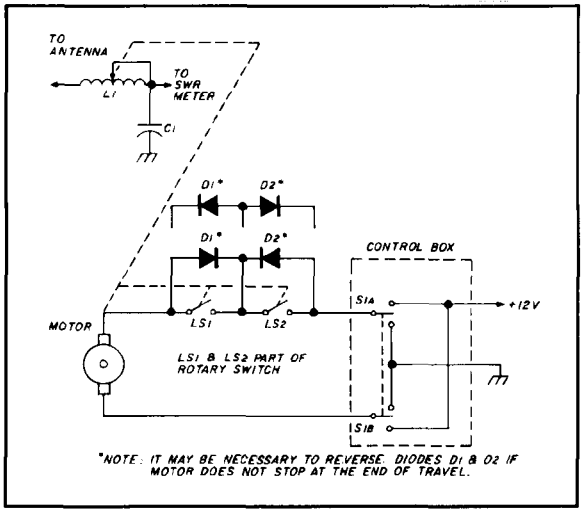
Use the steps that follow to modify the surplus assembly. Remove the top section of the rotary switch; you won't need it. Remove all the wiring from

FIGURE 1



Schematic diagram of the 75-meter remote tuner.

FIGURE 2



Detailed schematic of the limit switch for the roller-inductor drive motor.

parts list

D1,D2 = 1N4003
C1 = 1000 to 1200 pF mica depending on band of coverage on 80 meters. 500 to 600 pF mica for 40-meter coverage.
S1 = DPDT switch center off
Motor Driven Roller Inductor, part no. L401/180L is available from Fair Radio Sales Co., P.O. Box 1105/1106 E. Eureka Street, Lima, Ohio 45802. The price is $29.95.

the remaining switch section and the motor. A large resistor is mounted on the motor support. This, too, is unnecessary and should be removed. The motor with the resistor in series was designed to run on 24 volts; by removing the resistor you can use it on 12 volts. If you find that the tuner adjustment is too fast, reinstall the resistor and it will slow the tuner down. Reassemble the remaining switch section with the original hardware and rewire it by adding two steering diodes (D1 and D2), as illustrated in **fig. 2.** It may be necessary to reverse the diodes if the motor doesn't stop at the end of travel.

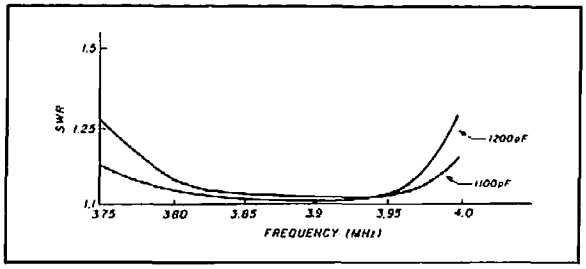
I mounted the motor control box on top of my radio console and used a DPDT center off switch to control the motor. You should mark the control box to

indicate the direction of rotation (which raises the frequency of resonance and which lowers it). Then, taking 12 volts from the ignition switch and routing it to the box, I ran a two-conductor cable back to the tuner at the rear of my car.

A 20-gauge two-conductor cable is all you need to control the motor, as it draws only about 0.2 to 0.3A. Those of you who have automatic tuners in your rigs have probably found that they are quite limited in the amount of SWR they can handle; for those of you who don't, this one will solve all your problems. I have used three of these tuners in my car, my camper, and at home at the base of my 35-foot vertical for tuning 40 and 80 meters.

The tuner tucks away nicely in the rear of my car. I have used this unit successfully in two automobiles with no additional changes. If you wish to operate on 40 meters, just change the shunt capacitance at the input to the tuner. Select this capacitor so you can tune the entire phone band with the appropriate inductance. On 80 meters I used an 1100-pF mica cap; on 40 you'll want to start with about a 500-pF mica cap. Remember to tune your antenna at the top end of the band with no inductance added, then increase the inductance as you tune lower in frequency. On 80 meters I was able to indicate a minimum SWR of 1.2 to 1 at 4 MHz and 1.1 to 1 across the band until I got to 3.8, where it started to rise again to 1.2 to 1. Increase the shunt capacitance to 1200 pF to shift the curve lower; change the cap to 1000 pF to raise the curve (see **fig. 3**).

FIGURE 3



VSWR response curves for the two capacitor values indicated.

The last time I talked with Fair Radio there were plenty of these tuners in stock. Let me know if you have any questions and/or enjoy this little tuner. '73 for now and happy mobiling.

Article C **HAM RADIO**

COMPUTERIZE YOUR SHACK

YAESU 747, 757GX, 757GXII, 767, 9600.
KENWOOD TS 140, 440, 940, 680, R5000.
ICOM R71A, R7000, 735, 751A, 761, 781, AND ALL VHF, UHF, CI-V.
DRIVERS FOR RADIOS ARE MODULAR.
JRC NRD 525.

COMPLETE PROGRAM ENVIRONMENT.
MENU DRIVEN AND DESIGNED FOR EASE OF USE.
SCAN FUNCTION ADDED TO RADIOS THAT DO NOT SUPPORT IT.
ERGONOMETRICALLY DESIGNED FOR EASE OF OPERATION.
MOST FUNCTIONS REQUIRE SINGLE KEYSTROKES.
PROGRAM COLOR CODED FOR EASE OF USE, ALTHOUGH WILL STILL RUN IN A MONOCHROME SYSTEM.

MENUS FOR THE FOLLOWING:
AMATEUR HF—AMATEUR VHF— AMATEUR UHF
AM BROADCAST—FM BROADCAST—TELEVISION BROADCAST
SHORT WAVE BROADCAST
AVIATION HF(SSB)—AVIATION VHF—AVIATION UHF
HIGH SEAS MARINE—VHF MARINE
MISCELLANEOUS HF, VHF, UHF
MOST POPULAR FREQUENCIES ALREADY STORED
ADDITIONAL LIBRARIES AVAILABLE
COMPLETE LOGGING FACILITY
ALL FREQUENCY FILES MAY BE ADDED TO, EDITED OR DELETED

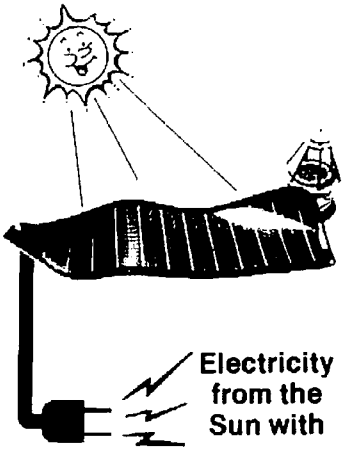
AVAILABLE FOR IBM PC, XT, AT, 80386 256K RAM
1 SERIAL PORT AND 1 FLOPPY MINIMUM

PROGRAM WITH INITIAL LIBRARIES	**99.95**
RS-232 TO TTL INTERFACE ONLY (NEEDED IF DON'T HAVE MANUFACTURERS INTERFACE)	
EXTERNAL INTERFACE ALLOWS 4 RADIOS	**99.95**
INTERNAL PC INTERFACE W/1 SERIAL & 1 RADIO PORT	**129.95**
SPECTRUM ANALYZER MODULE	(CALL FOR PRICE)
COMPLETE SYSTEMS INCL RADIO, INTERFACE, COMPUTER, AVAILABLE	(CALL FOR PRICE)

DATACOM, INT.
8081 W. 21ST LANE
HIALEAH, FL 33016
AREA CODE (305) 822-6028

122

LET THE SUN DO THE WORK



Electricity from the Sun with

SOVONICS ™
Solar Systems

- Charge batteries on stored machinery
- Light your tent
- Run fans
- Run remote transmitters
- Light signs
- Pump water for your animals
- Power for your motor home
- Run your radio without batteries
- Light your home
- Yard lights
- Charge flashlight batteries
- Light your cabin
- Run electric fences
- Charge your boat battery
- Run appliances in your home
- Charge hand held radio batteries
- Fish shanty lights
- Charge your Camcorder battery pack

ALSO: *OUTSTANDING* PRICES ON IBM XT COMPATIBLE SYSTEMS!

SHIPPING INFORMATION: PLEASE INCLUDE 10% OF ORDER FOR SHIPPING AND HANDLING CHARGES (MINIMUM $2.50, MAXIMUM $10). CANADIAN ORDERS, ADD $7.50 IN US FUNDS. MICHIGAN RESIDENTS ADD 4% SALES TAX. FOR *FREE* FLYER, SEND 22¢ STAMP OR SASE.

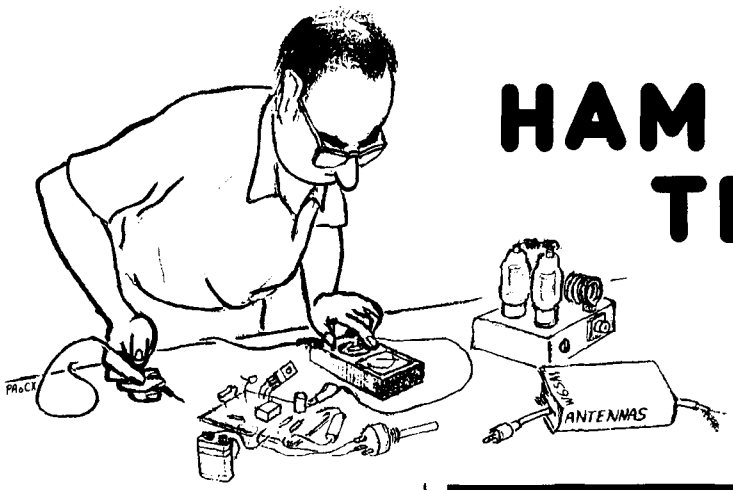


HAL-TRONIX, INC.
12671 Dix-Toledo Hwy
P.O. Box 1101
Southgate, MI 48195

(313) 281-7773
Hours
12:00 - 6:00 EST Mon-Sat

"HAL" HAROLD C. NOWLAND
W8ZXH

123



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

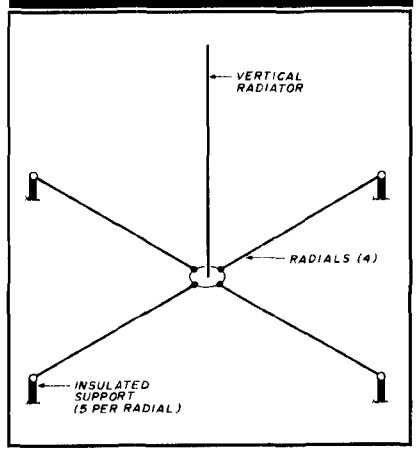
A look at the ground-plane antenna

In April I discussed "Vertical Monopoles With Elevated Radials" by Christman, Radcliff, Adler, Breakall, and Resnick.[1] Their work summarized computer studies indicating that a vertical monopole antenna with four elevated horizontal radials produces more groundwave (low angle) field strength than a conventional ground-mounted monopole with 120 buried radials. The monopole and radials were all a quarter wavelength long and the frequency of operation was 1.0 MHz. Base heights between 5 and 20 meters were investigated. Three different ground constants were used simulating average, very good, and very bad soil conductivity. For average soil, a radial height of 6 meters provided superior performance; for poor soil, a height of 8 meters was required.

The study concluded that "the use of elevated radials would provide superior performance, allowing the collection of electromagnetic energy in the form of displacement currents rather than forcing it to flow through lossy earth in the form of conduction currents."

Figure 1 shows the physical configuration of this antenna design. My remarks on the subject brought letters from readers asking for more information. There seems to be a great deal of interest in 160-meter vertical antennas.

FIGURE 1

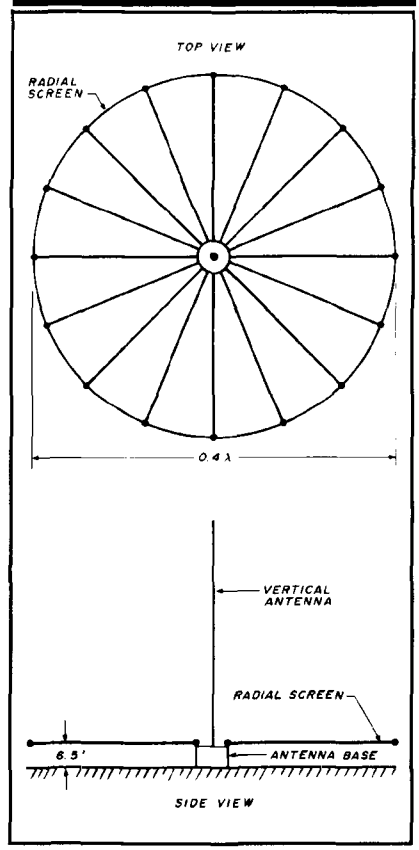


Layout of elevated radial system. Radial height is 6-8 meters at operating frequency of 1 MHz.

The concept of above-ground radial wires has been around for a long time. Experiments conducted by Doty, Frey, and Mills[2,3] and outlined in the 1982 bulletin of the Radio Club of America (later written up in the February 1983 issue of *QST* and also in my column), determined that the traditional ground radial system composed of a number of buried or surface wires can be equaled or bettered by using an elevated ground screen about 6.5 feet off the ground. This is shown in fig. 2. Note that this height is much less than that indicated in the layout of fig. 1.

Although the execution of this ground system is slightly different from

FIGURE 2



The ground radial system of Doty, et al. uses 50 radials, at least 0.2-wavelength long and 6.5 feet above ground.

the design shown in **fig. 1**, the concept seems to be the same. According to Edward Laport, former vice president of RCA and author of *Radio Antenna Engineering*, "All earth currents should enter the ground wires as displacement currents rather than conduction currents."

Enter the ground-plane antenna

The antennas shown in **figs. 1** and **2** are similar to the conventional ground-plane antenna. Then why all the fuss? A closer look at the ground-plane concept may clear the air. An excellent discussion of the ground-plane antenna was given in the "Technical Topics" column by Pat Hawker, G3VA, in the July 1981 issue of *Radio Communication*.

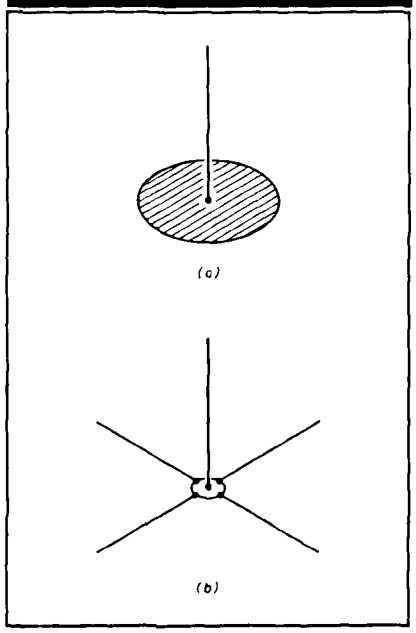
Pat points out that conventional wisdom (the *ARRL Antenna Handbook*, for example) claims that in order to obtain an omnidirectional pattern, the ground plane requires a metal ground disc with a quarter-wavelength radius (**fig. 3A**). The disc can be simulated with at least four straight radials equally spaced around a circle (**fig. 3B**). This implies that, as with buried radials, the more above-ground radials the better. It also suggests that such an antenna cannot be expected to function efficiently with an omnidirectional pattern with only one or two radials.

Pat refers to R.C. Hills, G3HRH, who asserts that the radial system of the normal elevated ground plane has little to do with the angle of radiation, but only provides a convenient low potential connection for the shield of the coax line. Hills states that the radials are electrically very transparent and the ground below the radials is well illuminated by the vertical antenna, so the presence of a good ground system is just as important as if the antenna were fed against ground.

G3VA comments on Hills saying, "Here the casual reader would assume that the use of four or more radials plus an extensive earth system buried in ground of good electrical conductivity was advisable to obtain optimum results."

In summary, G3VA points out that the effectiveness of any vertical antenna in providing low-angle radiation depends to a very marked extent upon earth conductivity. But an earth system that really meets this requirement can't use a normal buried earth system because it should extend many wavelengths around the antenna, in all directions.

FIGURE 3



Solid ground plane having 1/4-wavelength radius (A) can be simulated by four radials, each 1/4-wavelength long (B).

Getting down to basics

The conclusion is that ground conductivity is very important, but this does not answer the puzzle of the number of radials required. As G3HRH pointed out, their prime job is to provide an rf ground point for the coax line and to bring the antenna system to resonance. So why four radials? Why not five? Or three? Or perhaps one?

Pat, G3VA, had the enviable opportunity to meet Dr. George Brown of RCA, the man responsible for the development of the ground-plane antenna. On Dr. Brown's visit to England, Pat put the question to him. Here's what Pat had to say about this conversation:

"He (Brown) told me that the elevated ground-plane antenna was first devised in the thirties to meet an early requirement for police communications around 30 to 45 MHz. Its success was immediately evident when, at the first demonstration, the transmissions reached well beyond the anticipated service area. Now the important point was that the original design had only two radials; however, when it came to marketing the design the sales engineers reported that they could not persuade potential users that a two-radial antenna, with the two radials looking like a half-wave dipole, could possibly have an omnidirectional radiation pattern. On the classic principle that the customer is always right, George Brown *and his colleagues* simply added two more radials — and everybody was satisfied."

Pat's conclusion is that all that's required for the ground-plane antenna to function effectively is that the bulk of the horizontal radiation from the radials is cancelled out — and this happens with only two radials. This doesn't prove that four may not be better, but it is an indication that a two-radial ground plane certainly serves the purpose the inventor had in mind!

Separating the two problems

The experiments outlined in **fig. 1** indicate that a radial system is required for a vertical antenna in the vicinity of the earth. They show that a low, but elevated, system of radials is more efficient than a buried system. The data of **fig. 2** point to the same conclusion but indicate that a maximum of only four radials need be used, as opposed to a multiple radial design.

Looking at Dr. Brown's comments with reference to his original design, it is safe to assume that his ground-plane concept envisioned the antenna mounted several wavelengths in the air. The frequency of operation and the need for coverage to the horizon dictated that as great a height as possi-

ble be used. Two radials did the job in this special case. Since the antenna was high above the earth, the return currents entered the radials as displacement currents, and the conduction currents in the earth were quite low because of physical separation of earth and antenna.

It seems to me that a ground-plane antenna for VHF and hf use, mounted well above the ground, requires but two radials for good omnidirectional performance. On the other hand, when the base of the antenna is mounted close to the ground, the probability of return currents entering the ground as displacement currents is very high.

Dr. Brown's original work on buried ground radials was done in 1936-37. As Arch Doty, K8FCU, says in his article[2] "Dr. Brown's paper on buried radial wires used with vertical antennas is a true 'classic' work, the excellence of which has established practices in the field ever since. Unfortunately, its very completeness discouraged further research in the area, and the fact that it considered only one of the several possible methods of making artificial ground systems was overlooked."

The Doty, Frey and Mills group and the Christman, Radcliff, Adler, Breakall, and Resnick group have attacked the problem of above-ground radial systems using different methods. The former made physical experiments and conducted ground current measurements using relatively low radials. The latter group employed computer-modeling techniques and investigated field strength using radials at a greater height above ground. Unfortunately, neither group worked with the same radial configuration. Generally speaking, the broad result of both investigative groups was that elevated radials were superior to buried ones.

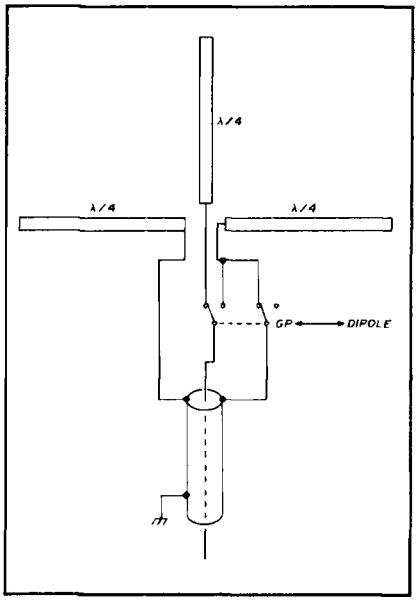
The first group indicated that 50 elevated radials, at least 0.2 wavelength long and about 6.5 feet above ground, are as effective as 120 buried uninsulated wires. The second group indicated that four radials, about 6 to 8 meters above ground and 0.25 wavelength long, "produce more groundwave field strength" than 120 buried radials. The first group measured the distribution of ground return currents. The second group examined the radiated field strength by computer. That study indicated that there was very little improvement going from four to 120 above-ground radials.

It remains for future experimenters to study the elevated radial situation. Perhaps a compromise can be found that produces good results with a minimum number of low radials.

A ground-plane dipole combination

The concept of using only two radials for a ground-plane antenna leads to the idea of a remote switching scheme like that shown in **fig. 4**. This will permit the operator to switch from the elevated ground plane (vertical polarization) to a dipole (horizontal polarization) from the operating position. It might provide an answer to the ongoing question: which performs best, a dipole or a ground-plane antenna?

FIGURE 4



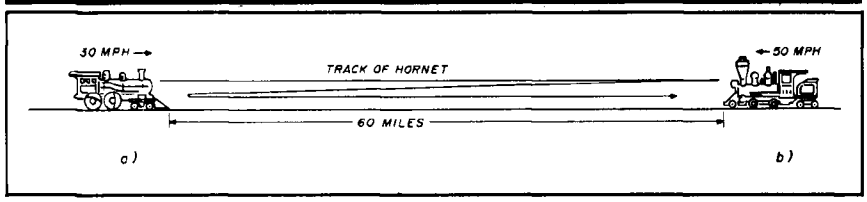
Remote double-pole double-throw relay switches from ground plane to dipole antenna.

The "Dead Band" Quiz

Here's an age-old problem for the mathematics buff (see **fig. 5**). Engine A and engine B are on the same track on a collision course. They are 60 miles apart. Engine A is going 30 miles per hour and engine B is going 50 miles per hour.

A fast hornet starts on engine A and flies to engine B, back to engine A, back to engine B, and so on. Eventually the hornet is killed when the two engines collide. The hornet flies at 400 miles per hour. Neglecting the turnaround time of the hornet, wind, and other minor delays, how many miles does the hornet fly before it's killed in the collision?

FIGURE 5



Engine and hornet problem is this month's quiz.

Send me your answer to this problem. My address is Box 7508, Menlo Park, California 94025. The calls of the math buffs who provide the most persuasive solution to this puzzle will be given in this column.

References

1. Christman, at al, "Vertical Monopoles With Elevated Ground Systems," Proceedings of the Third Annual Review of Progress in Applied Computational Electromagnetics, Naval Postgraduate School, Monterey, California, March 1987.
2. Arch Doty, "Antenna Efficiency. Is a Ground the Best Ground?" Bulletin, Radio Club of America, November 1982.
3. Doty, Frey, and Mills, "Efficient Ground Systems for Vertical Antennas," *QST*, February 1983, page 20-25.

Article D **HAM RADIO**



HAM PERFECT v 1.0

Action Software has released HAM PERFECT a new MS-DOS program for the Radio Amateur. The program will operate on all MS-DOS computers using DOS 2.1 or later and 256 K of internal RAM. HAM PERFECT is menu driven and includes the following antenna design programs: long wire, vertical, inverted V, tuned transmission lines, electrical length of harmonic wire, and dipole antennas.

A VSWR menu for system evaluation and three DX programs — call area, grid selection, and bearing and distance — is also included. Call area instantly locates any call area, city, or state out of a data base containing 476 records. Displayed are: distance and bearing, sunrise and sunset times, and grid coordinates. Grid selection converts grid to coordinates and vice versa. Bearing and distance gives great circle calculations between any two points on the surface of the earth.

HAM PERFECT sells for $49.00 and is available from Action Software, P.O. Box 12519, Tucson, Arizona 85718.

Circle #309 on Reader Service Card.

CODEMASTER© Morse code software package

Greenlight Software Development announces CODEMASTER© — their new Morse code software package. The program is IBM compatible and designed for users, from novice to master.

Key features include:

- Menu-driven program for easy selection and use of all facilities.
- One-touch online help function.
- Windowed operating environment for simple manuevering.
- Escape key for interruption and backtracking.

CODEMASTER© is $19.95 postpaid and available exclusively from Greenlight Software Development, P.O. Box 2591, Eugene, Oregon 97402.

Circle #310 on Reader Service Card.

New added feature card PK-8 for the CS64S Super Comshack 64

Engineering Consulting's model PK-8 adds new features to the Model CS64S Super Com Shack repeater controller for the C-64. The PK-8 option card makes user-defined talking meters possible. Up to 2 meters per parameter file may be defined (up to 18). Inputs are provided for talking S-meters, temperature, and battery voltage; any other varying voltages can also be sampled and spoken to the user. The PK8 increases to 16 the total number of external devices which may be activated from your touchtone commands. Two alarm inputs allow real-time Macro commands or may be used to execute alarm messages, whenever these alarm pins are grounded.

The model PK-8 is priced at $149.95. For more information contact Engineering Consulting, 583 Candlewood Street, Brea, California 92621.

Kantronics KT series and 2.84 firmware option

Kantronics, Inc. has introduced SSB, CW transceivers. There is one each for 80, 40, 20, 15 and 10 meters.

The Kantronics KT series features are noise blanker, 20-watts PEP output, LED digital readout of the entire band in 100 Hertz steps, and receiver incremental tuning (RIT).

Kantronics has also announced a 2.84 firmware option for KAM, KPC-4, KPC-1, KPC-2, and KPC-2400 units:

- Battery Backup for PBBS contents (B.B. "smart socket," and 32K RAM 62256 are extra).
- Protection of PBBS contents during soft reset (changing MAXUsers or NUMnodes will not erase PBBS, battery backup not required).
- Direct keyboard entry of messages into PBBS (limited only by RAM allocation to PBBS).
- PBS subject field (user is prompted for a subject for message).
- Help available from PBBS and KA-Node (gives short description of how to use).
- Enhanced (J)Heard and (N)odes Heard.
- KA-Node recognition of NETROM™ network nodes in its Nodes Heard list.

All Kantronics customers who purchased a Kantronics TNC after March 1, 1988, are entitled to a free 2.84 EPROM. You must provide proof of purchase and request 2.84 when you mail in your warranty card. Be sure to provide the model, firmware level, and RAM part number. If battery backup of RAM is desired, the Battery Backup "Smart Socket" *must be used with a 62256 static RAM!* We strongly suggest using a 32K RAM even if you don't plan to use the battery backup. Both of these are available at extra cost from the factory.

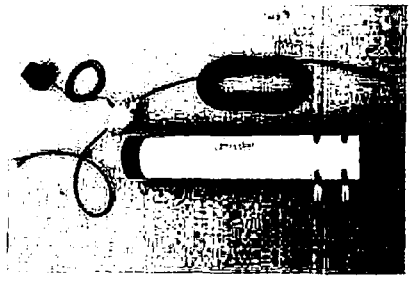
Cost varies from unit to unit, and with the current version level of each.

Contact Kantronics, Inc., 1202 E. 23rd Street, Lawrence, Kansas 66046 for details.

Circle #311 on Reader Service Card.

Dressier ara 900 VHF/UHF receiving antenna

The Dressler ara 900 is a VHF/UHF active receiving antenna capable of capturing signals from 50 to 900 MHz. The ara 900 cylinder has an etched circuit board, wideband amplifier, and impedance-matching network. The antenna's linear characteristics give it excellent intermodulation performance, negative feedback, and a low noise figure. Dimensions are 19-3/4″ x 3-5/8″ diameter; it can be mounted indoors or



out. The supplied lead-in coax is 25′ long and can be replaced by any length coax with PL-259 fittings up to 100′. The coupler terminates in an N-type connector fitting scanners like the Icom R-7000 receiver. Price including power adapter is $189 plus $8 shipping and handling. It is distributed by Gilfer Shortwave, 52 Park Avenue, Park Ridge, New Jersey 07656.

Circle #312 on Reader Service Card.

Hamtronics® 900 MHz transmitters

Hamtronics, Inc. has announced a series of transmitters for the 902-928 MHz ham band which complement the R901 FM Receiver.

The new TA901 Exciter runs a minimum of 1/2 watt output, sufficient to run barefoot on short to medium length paths or to drive the new LPA901 Power Amplifier. The TA901 is basically a modified version of the TA451 UHF FM Exciter but a doubler, driver, output stage line-up using surface mount microwave transistors and capacitors replace the usual predriver, driver, and output stages.

The LPA901 Power Amplifier uses a standard heatsink (as on the LPA 2-15 Power Amplifier for the vhf bands) and a broadband power module, which requires no tuning, to produce 8 to 10 watts output. It requires only 100 mW to drive from the exciter.

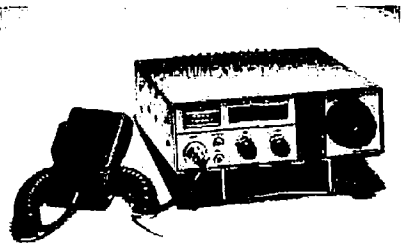
The TA901 Exciter and LPA901 Power Amplifier are both available off the shelf at $269 each, wired and tested. (Because of their complexity, these units will not be offered in kit form.) A 902-MHz version of the popular Hamtronics® REP-100 Repeater is also available.

For more information on 900-MHz transmitters, contact Hamtronics, Inc., 65 Moul Road, Hilton, New York 14468-9535. A catalog of other fm transmitters, receivers, repeaters, converters, and preamps for vhf and uhf is available. Send $1.00 to cover postage or $2.00 for overseas mailing.

(continued on page 42)



(continued from page 41)



New SSB, CW transceivers

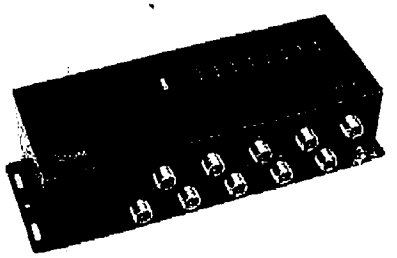
Kantronics, Inc. has introduced five single sideband, CW transceivers. One each for: 80, 40, 20, 15, and 10.

The Kantronics KT series transceiver features 20-watts PEP output, LED digital readout of the entire band in 100-Hz steps and receiver Incremental tuning (RIT). Ask your Kantronics Authorized Dealer for information or contact Kantronics, Inc., 1202 E. 23rd Street, Lawrence, Kansas 66046.

Circle #301 on Reader Service Card.

EX-627 hf automatic antenna selector

ICOM now offers the EX-627 HF Automatic Antenna Selector which automatically selects the correct antenna for an ICOM hf transceiver's operating frequency. You can access up to seven antennas by simply pushing one button on the selector.



The EX-627 antenna selector:

- can be used with any transceiver to manually select up to nine antennas,
- includes conectors for a linear amplifier or antenna tuner,
- has power supplied from the transceiver through a provided accessory cable,
- comes with hardware to mount the EX-627 on the wall, the side of a desk, etc.

The suggested retail price for the EX-627 is $315.00. For more information contact ICOM America, Inc., 2380 116th Avenue, NE/P.O. Box C-90029, Bellevue, Washington 98009-9029.

Circle #303 on Reader Service Card.

Alinco Electronics Inc.

introduces a new line of transceivers, the DJ series hand helds.

Features include:

- Ten memories.
- LCD illumination.
- Dip switch programmable sub-tones. Easily accessible dip switch is mounted on the back of the transceiver.
- Offset storage in memories.
- Built-in dc/dc converter with standard NiCd and others.
- Multiple battery packs. 2.5 watts from the factory; 6.5 watts output with optional 12 volt NiCd.



- Sixteen button DTMF pad.
- BNC antenna connection.
- Frequency coverage easily expandable for CAP and MARS.

The suggested list price of the DJ series transceivers is $299.00.

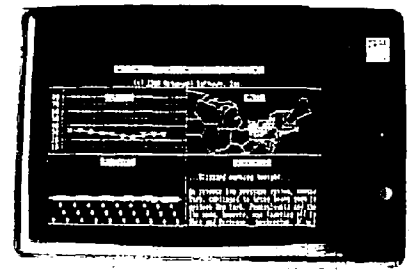
For more information contact Alinco Electronics Inc., 20705 South Western Avenue, Suite 104, Torrance, California 90501.

Circle #302 on Reader Service Card.

Accu-weather forecaster

Metacomet Software in collaboration with Accu-Weather Inc., State College, Pennsylvania, has just announced release of its ACCU-WEATHER FORECASTER software for MS-DOS computers.

ACCU-WEATHER FORECASTER is a menu driven program that allows the user to tap into



Accu-Weather's extensive computerized database. In addition to Accu-Weather's forecasts, you can get hourly updates from National Weather Service Offices nationwide.

Maps, graphs, pictures, charts, and narrative descriptions are just part of what can be downloaded to your MS-DOS computer. To save telephone and hook-up charges, tell your computer exactly what information you want. Then call ACCU-WEATHER; the computer will download the files you want and save them to disk. Information can be obtained for the entire United States or a specific geographical region.

Several different services are available from ACCU-WEATHER. Price varies with the service and time of day that the computer is accessed.

The IBM and Macintosh versions sell for $89.95. ACCU-WEATHER is available from Metacomet Software, P.O. Box 31337, Hartford, Connecticut 06103 or the *ham radio* Bookstore. Add $3.50 for shipping and handling.

Circle #304 on Reader Service Card.

144/220-MHz FM dual bander

Kenwood's all new 144/220-MHz FM Dual Bander TM-621A includes a dual channel watch function, selectable full duplex operation, 30 memory channels, extended frequency coverage, large multi-color dual digital LCD displays, and programmable scanning, with 45 watts of output on 144 MHz and 25 watts on 220 MHz.

- Extended receiver range (138.000-173.995 MHz) on 2 meters; 1-1/4 meter coverage is 215-229.995 MHz. (Specifications guaranteed on Amateur bands only. Transmit range is 144-147.995 MHz; and 220-224.995 MHz. Modifiable for MARS/CAP. Permits required.)
- 30 multi-function memory channels. 14 memory channels and one call channel for each band store frequency, repeater offset, CTCSS, and reverse. Channels "A" and "b" establish lower and upper limits for programmable band scan. Channels "C" and "d" store transmit and receive frequencies independently for "odd splits."
- Automatic offset selection on both bands.
- Dual frequency display for "main" and "sub-band."
- Automatic Band Change (A,B,C) automatically changes between main and sub-band when a signal is present.

(continued on page 102)

PATHFINDER
PART TWO

By Ron Todd, K3FR, 7 Hillcrest Road, Windham, Maine 04062

Add output option menu and file access functions for complete operating aid

When I originally defined PATHFINDER[1] I wanted a program that would bring together three major utilities regularly used to map hf operating activities: MINIMUF[2], bearing/distance, and grey-line summary. Part 1 showed how these three seemingly different functions all rely on the same basic set of mathematical routines, and presented the core program of PATHFINDER. If you've read part 1, you know that PATHFINDER is a menu-driven program that reports bearing and distance, home and target terminator events, MUF for short and long path to the target specified, and the radial MUF for a given time and path length. Conditions may be changed and analysis selected at will to provide a general view of propagation modes and conditions. However, PATHFINDER is cumbersome to use because coordinates must be entered manually.

The *ARRL Antenna Handbook* is a handy reference for your target coordinates.[3] At the back of the book is a listing of DXCC countries with their geographic coordinates. But, when using a reference table of location coordinates, there's still the chance that you might enter a coordinate incorrectly and waste time rerunning a simulation. There are two other features PATHFINDER might provide once you've established a latitude/longitude data file. These are a global summary report of grey-line conditions from your home location to any location in the data file which has terminator concurrency, and a summary listing of bearing and distance from the home QTH to all locations in the data file.

This month I'll give you a program to generate a data file of prefix, location name, and geographic coordinates. I'll also include the appropriate code to insert into PATHFINDER to allow either case specific or global access to this data file. The case *specific feature* eliminates the need to maintain a desk reference when using PATHFINDER in a point-to-point mode. Global access lets PATHFINDER generate the world bearing and distance report, or report all QTHs on or near your grey line. I've added an expanded hard copy function which is accessed through a second menu level when you want printer output. The menu provides selection of either a chart or tabular format report of the latest MUF run, or a listing of the current conditions and locations defined.

Getting more out of PATHFINDER

The charting feature of the expanded hard copy function is, like the current list feature, built around the array MOUT which is loaded during each analysis run. The current list option of the top level menu sent the data in this array to your printer. The charting option does the same, but presents the MUF data in a simple graphic form by tabbing your printer to a specific column. In the MOUT (36) array the index is equivalent to the independent variable of the analysis, while the array content is the analysis result for each increment of the independent variable. Choose the hard copy report function after each MUF run to get your report. The tabular report is still presented on screen as the analysis is running, so you can choose to output the report or run further analyses until you have one you want to keep.

Those of you using the hard copy function have noted that the conditions under which the MUF is reported aren't listed to the printer. A third option is added to the new hard copy second *level menu to allow printout of* this information. With only the output enhancements added, the new top level menu looks like:

Opt: 1 = Input 2 = Anal 3 = Output 4 = Quit

and the output function select menu shows the selections available:

Opt: 0 = Top 1 = Table 2 = Chart 3 = Data

Figure 1 gives the steps and lines required to add these features to your copy of PATHFINDER, along with

FIGURE 1

```
Modifications to PATHFINDER to add chart and data output to
line printer routines.

Replace line 200 with:

200 INPUT "Opt: 1=Input 2=Anal 3=Output 4=Quit ";IO

Replace lines 290 thru 320 with:

290 INPUT "Opt: 0=Top 1=Table 2=Chart 3=Data";IO
300 ON IO GOSUB 310,350,390: GOTO 200
310 LPRINT "GMT/DEG","MUF","GMT/DEG","MUF"
320 FOR IH=0 TO I-1: FOR IB=0 TO 1 STEP 1

Add new lines 330 thru 450.

330 LPRINT (IH+IB)*IA,MOUT(IH+IB),
340 NEXT IB: LPRINT: NEXT IH: RETURN
350 FOR IH=0 TO 2*I-1
360 LPRINT (IH*IA);TAB(6+INT(MOUT(IH)));"*": NEXT IH
370 LPRINT "     |0    |    |10   |    |20   |    |30   |    |40   |    |50"
380 LPRINT: RETURN
390 LPRINT "Path length =";INT(G1*3959);"miles"
400 LPRINT "Path bearing at home QTH =";INT(PB*R1)
410 LPRINT "DATE: "MID$(M$,3*M0-2,3)" "D$
420 LPRINT "HOME AT LAT"LH"LONG"WH" TARGET AT LAT"LT"LONG"WT
430 LPRINT "SOLAR FLUX="SX" SUN SPOT NUMBER="S9
440 IF IL=2 THEN LPRINT "TIME: ";INT(40*INT(T5)+60*T5)/100,"Z"
450 RETURN
```

Modifications to PATHFINDER to add chart and data output to line printer routines.

FIGURE 2

```
Modifications to PATHFINDER to accelerate GREY-LINE computations

Change lines 1300 and 1310 to:

1300 W0=W1: L0=L1: GOSUB 5100: PRINT "At home QTH"; OOPUB 7000
1310 GOSUB 6420: W0=W2: L0=L2: GOSUB 5100: PRINT "At targ QTH"

Replace lines 5000 thru 5040 with:

5000 GOSUB 5100: IF C0(I)<-86 THEN 5040                    'SOLAR CHAR
5010 IF C0(I)<.62094 THEN T9(I)=.1 ELSE T9(I)=9.7*C0(I)^9.6
5020 X=X9(I)/T9(I): X=(X-INT(X))*2*PI: G0(I)=COS(L0)*COS(X)+SIN(L0)*SIN(X)*COS(W0-W2): GOSUB 6100
5030 Z8(I)=(SX*(-X)+1)*SH(I)*GB(1): G7(I)=SX*((X9(I)-24)/2)*S$(I)
5040 RETURN

Delete lines 5050 thru 5090.

Replace lines 5100 and 5110 lines with:

5100 X9(I)=0: X=L0+Y2: C0(I)=COS(X): C0A=COS(6*X/7)        'DAY CHAR
5110 IF C0(I)<-86 THEN 5170 ELSE R6=6*(2+W0*P2)-BT          'DAY CK

Add new lines 5120 thru 5170:

5120 IF E6<0 THEN E6=E6+24 ELSE IF R8>=24 THEN E6=R8-24     'NOON
5130 X=COS(Y2)*COS(L0): IF X<.00001 THEN X=.00001
5140 X=(SIN(Y2)*SIN(L0)-B6)/X: GOSUB 6000: X=6*X+P2: X9(I)=2*X
5150 S8(I)=X8-X: IF S8(I)<0 THEN S8(I)=S8(I)+24             'SUNR
5160 S8(I)=R8+X: IF S8(I)>=24 THEN S8(I)=S8(I)-24           'SUNS
5170 RETURN
```

Modifications to PATHFINDER to accelerate GREY-LINE computations.

the changes and additions needed to *add the* expanded hard copy functions to the program. The scope and nature of these changes have been limited to add, delete, and replace functions. If you use a word processor, note that some of these and the later changes amount to no more than renumbering and moving some lines so that they occur in a revised sequence. This can save you some time in implementing these enhancements. If you don't use your word processor for this task, input new lines to your BASIC rather than using its RENUM command. The RENUM command will renumber all lines beyond the first target number and cause all sorts of headaches when you implement the rest of the features.

At this point you can choose either a tabular or a chart format printer listing of MUF. You can also obtain a list of the current input data so that you won't have to annotate your listings in order to remember what the output is telling you. I assume you all have fat fingers like me and would benefit from some debugging; it would be a good idea to practice the new PATHFINDER features before continuing on to the data file access features.

Blazing speed

The grey-line daylight characterization routine in PATHFINDER wasn't optimized in the original version. This makes little difference when you're doing individual specific grey-line evaluations, but will slow down the grey-line summary when it's added. **Figure 2** shows modifications that create a separate subroutine to compute the solar events and merge this routine into the one needed to determine the solar driven parameters for MUF computations. Again, the changes may be done with your word processor working on an ASCII version of the program.

Data makes THE difference

PATHFINDER's prime limitation in its original form

FIGURE 3

```
Program to create or edit a sequential data file.

10 DEFINT I    'PROGRAM GENDAT.BAS, RCT 4/11/88
20 INPUT "Opt: 1=Add 2=Edit 3=Insert 4=Delete 5=New 6=EXIT";IO
30 ON IO GOTO 100,200,300,400,500,1000: GOTO 20
100 GOSUB 700: IF NOT EOF(1) THEN FYS="*": GOSUB 800  'ADD TO END
110 GOSUB 600: B$="": INPUT "<CR> to Continue, else Done";B$
120 IF LEN(B$)=0 THEN 110 ELSE 750
200 GOSUB 700: IF EOF(1) THEN 760                     'EDIT RECORD
210 INPUT "EDIT PREFIX: ";FYS: GOSUB 900: IF EOF(1) THEN 760
220 GOSUB 600: B$="": INPUT "<CR> to Continue, else Done"; B$
230 IF LEN(B$)=0 THEN 210 ELSE 750
300 GOSUB 700: IF EOF(1) THEN 760                     'INSERT RECORD
310 INPUT "ADD AFTER PREFIX: ";FYS: GOSUB 900: IF EOF(1) THEN 760
320 WRITE #2,FX$,Q$,L2,W2
330 GOSUB 600: B$="": INPUT "<CR> to Continue, else Done"; B$
340 IF LEN(B$)=0 THEN 330 ELSE 750
400 GOSUB 700: IF EOF(1) THEN 760                     'DELETE RECORD
410 INPUT "DELETE PREFIX: ";FYS: GOSUB 900: IF EOF(1) THEN 760
420 B$="": INPUT "D to Delete, else Reject"; B$
430 IF NOT (B$="D" OR B$="d") THEN WRITE #2,FX$,Q$,L2,W2
440 B$="": INPUT "<CR> to Continue, else Done"; B$
450 IF LEN(B$)<0 THEN 410 ELSE 750
500 OPEN "O",#1,"LATLONG.DAT": CLOSE #1: GOTO 20 'CREATE NEW FILE
600 INPUT "Prefix";FX$: INPUT "QTH";Q$                'CAPTURE DATA
610 INPUT "Latitude ";L2: INPUT "Longitude ";W2
620 PRINT "!... PLEASE CHECK DATA ...!"
630 B$="": INPUT "<CR> if OK, R to Redo, else QUIT";B$
640 IF LEN(B$)=0 THEN WRITE #2,FX$,Q$,L2,W2: RETURN
650 IF (B$="R" OR B$="r") THEN 600 ELSE RETURN
700 OPEN "I",#1,"LATLONG.DAT"                         'OPEN FILES
710 OPEN "O",#2,"TEMP.DAT": RETURN
750 FYS="*": GOSUB 900                'COPY REST OF FILE AND CLOSE ALL
760 PRINT "END of FILE": CLOSE #1: CLOSE #2: KILL "LATLONG.DAT"
770 NAME "TEMP.DAT" AS "LATLONG.DAT": GOTO 20
800 IF NOT EOF(1) THEN INPUT #1,FX$,Q$,L2,W2 ELSE RETURN  'SEARCH
810 IF FX$<>FYS THEN WRITE #2,FX$,Q$,L2,W2: GOTO 800 ELSE RETURN
900 GOSUB 800: IF EOF(1) THEN RETURN                  'FIND RECORD
920 PRINT "Found: ";FX$;" ";Q$;" Lat=";L2;" Lon=";W2
930 B$="": INPUT "<CR> if OK, N for NEXT, else to QUIT"; B$
940 IF LEN(B$)<>0 THEN WRITE #2,FX$,Q$,L2,N2 ELSE RETURN
950 IF NOT (B$="N" OR B$="n") THEN FYS="*"
960 GOTO 900
1000 B$="": I=0                                       'MAKE KEY FILE, EXIT
1010 OPEN "I",#1,"LATLONG.DAT": OPEN "O",#2,"LATLONG.KEY"
1020 IF EOF(1) THEN 1090 ELSE I=I+1: INPUT #1,FX$,Q$,L2,W2
1030 A$=LEFT$(FX$,1): IF B$=A$ THEN 1020 ELSE B$=A$: J=I-1
1040 IP=ASC(B$)-65: IF IP>31 THEN IP=IP-32
1050 IF IP>25 THEN 1020
1060 IF (IP>-18) AND (IP<-7) THEN IP=IP+43
1070 IF (IP>=0) AND (IP<36) THEN WRITE #2,IP,J
1080 GOTO 1020
1090 CLOSE #1: CLOSE #2: END
```

Program to create or edit a sequential data file.

was that you had to know the geographic coordinates of the target station. Many serious DXers keep a listing of bearing and distance information on their desks, or use some other operating aid to help point their antennas. Sometimes these indexes include the geographic coordinates at the location of interest; often they do not. Your computer gives you an excellent card box in which to keep this information. Next, I'll tell you how to get this information into PATHFINDER.

Your computer keeps its information in files on tape or disk. When you save program data to one of these

files, the operating system arranges and catalogs the data for you so that you can find it later. Generally there are two types of files used for this information storage: sequential and random. Sequential files can usually hold any type of information in any order, but data must be accessed in the same order as written from beginning to end. Random files can be accessed at will, but may contain only strings (character data) of fixed format. While random files allow quicker access to data stored deep in the file, more complex operations are usually required to get the data into and out of it. Additionally, some dialects of BASIC don't even implement random access files. I'll present only code to generate and access sequential files.

When generating your data file, you can choose from several sources of geographic coordinates to create the locations contained in that file. My own data file was taken from Overbeck and Steffen.[4] In addition to the ARRL publication mentioned previously, a world atlas (like those published by the Rand McNally Company or Encyclopedia Britannica, Inc.) can provide a source for the data you need. Your local library should have one of these references.

The listing in **fig. 3** is the code for GENDAT.BAS. This program creates and edits a sequential file called LATLONG.DAT that will hold the data PATHFINDER needs to set a target QTH. At the end of the program, GENDAT reads the file just edited and creates a key listing file. This file tells PATHFINDER approximately where in the data file it can find the prefix you enter, based on the first character of that prefix. The program requires that both LATLONG.KEY and LATLONG.DAT be on the default disk. This must be the same disk you are using to run PATHFINDER and BASIC.

GENDAT prompts you for the information it needs to build the data file. At the end of each entry, you'll be asked to verify the information you have supplied before the data is written to disk. Take this step seriously; any error in the data will reflect on PATHFINDER's accuracy.

Select NEW (item 5) at the first menu prompt the first time you run GENDAT. This assures the program that it will find a file when it needs to. After that you can add to the end of the file, edit an entry, insert an entry in the middle, or delete an entry by making the appropriate menu selection and answering the prompts. You needn't finish the job in one session; that's why there are selections for all functions. If you already have a satisfactory LATLONG.DAT file in the specified format, just invoke GENDAT and then select QUIT (item 6) at the first menu prompt. This will generate the key file from your current data file without changing the data file.

You can use a word processor in the program-writing mode instead of GENDAT as long as you enter the data in the order of prefix, QTH name, latitude, and longitude. But you'll have to quote the string fields (prefix and QTH name), separate each field with a comma, and terminate each line with a carriage return. GENDAT may not be as fast or as flexible as a word processor, but it does order and delimit the data for you. If you do use a word processor, make sure you build a small program to create the key file. The code for this is in lines 1000-1090 of GENDAT.BAS. Without the key file, PATHFINDER will either fail to function or, at the very least, will take more time in finding a QTH for you. If you are a good typist and feel comfortable with your word processor then go ahead and use it; otherwise, I highly recommend that you key in and use GENDAT.

Whichever way you choose to create your data file, the prefix *must* use capitals for *all* its alphabetic characters! Another thing to remember when preparing your data file is that you *must* group all locations according to the first character of the prefix (all G's together, all U's together, all 1's, etc.) Though it's not necessary to arrange these groups alphabetically, it's easier to do so as the searching process will run a little faster and the bearing/distance and grey-line summaries will print out in order. I haven't worked out a simple way to access a country without an assigned prefix (Abu-ail), so you'll have to code it as some strange numeric or alphabetic call; try "ABU" for instance. Do not, however, use an asterisk (*) for these calls; GENDAT uses this character as a default to terminate searches.

The keys to the kingdom

Now that you have data and key files, how does PATHFINDER use this information to set QTHs? In order to minimize the search time on the sequential LATLONG.DAT file, I have implemented a key file called LATLONG.KEY. This file has up to 36 integer pairs which tell PATHFINDER how far into the data file it must read before reaching an entry with the same first character as the prefix you're looking for. The keys are based on an ordinal value assigned to the letters of the alphabet and the numerals (letters from 0-25 and numerals from 26-35). The first integer in the pair is the ordinal value of the first letter/number of the prefix; the second integer is the number of records that must be read before the program can read a record with the same prefix first character.

When you enter a prefix to PATHFINDER's prompt, the program takes the first character in the prefix, determines its ordinal number in the same way GENDAT does, and then looks in the array IKEY for the index number corresponding to this character. Using this index number the program will open the LATLONG.DAT file, read and discard that many locations, and then start checking the prefix of the data file location for a match to the prefix you requested. When the program finds a matching prefix, it displays the location associated with it and checks with you to see if it's the one you want.

FIGURE 4

```
Pathfinder modifications to add data file access and summary menus

Replace lines 200 and 210:

200 INPUT "Opt: 1=Input 2=Anal 3=Output 4=File 5=Quit ";IO
210 ON IO GOTO 220,240,280,460,9999: GOTO 200

Add lines 72 thru 78.

72 DIM IKEY(35): OPEN "I",1,"LATLONG.KEY" 'LOAD KEY ARRAY
74 FOR IP=0 TO 35: IKEY(IP)=-1: NEXT IP
76 IF NOT EOF(1) THEN INPUT #1,IP,IKEY(IP): GOTO 76
78 CLOSE #1

Add lines 460 and 470.

460 INPUT "Opt: 0=Top 1=B/D 2=Grey 3=Target ";IO
470 ON IO GOSUB 500,600,800: GOTO 200
```

PATHFINDER modifications to add data file access and summary menus.

FIGURE 5

```
PATHFINDER modifications to add data file access functions.

Add lines 500 thru 580, 600 thru 780 and 800 thru 940.

500 OPEN "I",1,"LATLONG.DAT"          'BEARING/DISTANCE LIST
510 LPRINT "PREFIX" TAB(15) "QTH" TAB(48) "SHORT PATH" TAB(68) "LONG PATH"
520 LPRINT TAB(45) "BEARING DISTANCE" TAB(65) "BEARING DISTANCE"
530 IL=0: IF EOF(1) THEN 570 ELSE INPUT #1,PX$,Q$,LT,NT
540 LPRINT PX$ TAB(10) LEFT$(Q$,30);: GOSUB 8420
550 GOSUB 3000: I=45: IA=53: GOSUB 580: IL=1
560 GOSUB 3000: I=65: IA=73: GOSUB 580: LPRINT: GOTO 530
570 CLOSE #1: RETURN
580 LPRINT TAB(I) INT(PR*BL) TAB(IA) INT(GL*3959);: RETURN
600 I=1: IL=0: S6=0: H0=W1: L0=L1: OPEN "I",1,"LATLONG.DAT" 'GREY LIST
610 GOSUB 5100: IF C0(I)<-86 THEN PRINT "NO SUN AT HOME":GOTO 780
615 LPRINT "Home Sunrise at:";INT(40+INT(SR(I))+60+SR(I))/100;"Z"
620 LPRINT "Home Sunset at:";INT(40+INT(SS(I))+60+SS(I))/100;"Z"
625 LPRINT "PREFIX" TAB(15) "QTH" TAB(48) "AT SR" TAB(63) "AT SS"
630 LR1=SR(I)-.75: LR2=SR(I)+.75: LS1=SS(I)-.75: LS2=SS(I)+.75
640 IF EOF(1) THEN 780 ELSE INPUT #1,PX$,Q$,LT,WT: GOSUB 8420
645 L0=L2: W0=W2: GOSUB 5100: IF C0(I)<-86 THEN 640
650 INR=0: IS8=0: ISR=0: IS8=0: X=SR(I): Y=SS(I)
660 IF LR1<0 THEN IRR=((X-24)>=LR1): IRS=((Y-24)>=LR1)
665 IF LS1<0 THEN ISR=((X-24)>=LS1): IS8=((Y-24)>=LS1)
670 IF LR2>=24 THEN IRR=((X+24)<=LR2): IRS=((Y+24)<=LR2)
675 IF LS2>=24 THEN ISR=((X+24)<=LS2): IS8=((Y+24)<=LS2)
680 IF IRR OR IRS THEN 690
685 IRR=(X>=LR1)AND(X<=LR2): IRS=(Y>=LR1)AND(Y<=LR2)
690 IF ISR OR IS8 THEN 700
695 ISR=(X>=LS1)AND(X<=LS2): IS8=(Y>=LS1)AND(Y<=LS2)
700 IF (IRR OR IRS OR ISR OR IS8) GOSUB 720
710 GOTO 640
720 LPRINT PX$ TAB(10) LEFT$(Q$,30) TAB(45);
730 IF IRR THEN X=SR(I): AS="SR": GOSUB 770: GOTO 740
735 IF IRS THEN X=SS(I): AS="SS": GOSUB 770
740 LPRINT TAB(60);
750 IF ISR THEN X=SR(I): AS="SR": GOSUB 770: GOTO 760
755 IF IS8 THEN X=SS(I): AS="SS": GOSUB 770
760 LPRINT: RETURN
770 LPRINT INT(40+INT(X)+60+X)/100;"Z ";AS;: RETURN
780 CLOSE #1: RETURN
800 INPUT "PREFIX TO SEARCH FOR";PY$          'TARGET FROM FILE
810 IP=ASC(LEFT$(PY$,1))-65: IF IP>31 THEN IP=IP-32
820 IF IP>25 THEN PRINT "ERROR": GOTO 800
830 AS=CHR$(65+IP): IF (IP<-7 AND IP>-18) THEN IP=IP+43
840 IF (IP<0)OR(IP>35) THEN PRINT "ERROR": GOTO 800 ELSE IP=IKEY(IP)
850 OPEN "I",1,"LATLONG.DAT": IF IP<0 THEN 930
860 FOR I=0 TO IP: INPUT #1,PX$,Q$,LP,WP: NEXT I: GOTO 890
870 IF EOF(1) THEN 930 ELSE INPUT #1,PX$,Q$,LP,WP
880 IF LEFT$(PX$,1)>AS THEN 930
890 IF PX$<>PY$ THEN 870 ELSE PRINT "Found: "PX$" in "Q$
900 BS="": INPUT "<CR> if OK, N for NEXT, else to QUIT; BS
910 IF LEN(BS)=0 THEN LT=LP: WT=WP: GOSUB 8420: GOTO 940
920 IF (BS="N")OR(BS="n") THEN 870
930 PRINT "NOT Found"
940 CLOSE #1: I=1: RETURN
```

PATHFINDER modifications to add data file access functions.

Some prefixes have more than one location associated with them; you may check each one in sequence until you have selected the one you want. PATHFINDER continues this activity until the prefix no longer matches and then closes the file. You can cut this process short by telling the program to terminate the search. When you accept a location, PATHFINDER copies the latitude and longitude to the target location and then returns to the top level menu.

The index array is built once at the beginning of the program execution by reading in the key values from the LATLONG.KEY file. Some prefix first characters (M, Q, etc.) may not occur in the data file. GENDAT doesn't store a data pair for these characters; PATHFINDER handles this situation by preloading the IKEY array with a default value which is overwritten by those locations which do occur. When you input a nonoccurring prefix PATHFINDER extracts the default value from the array and, knowing that the prefix does not exist, it then exits the search function.

Now add the code for the data file access. **Figure 4** details the changes which must be made to the top level menu — the additional lines needed to declare and load the key array and the additional program lines that define and implement the file level menu. These changes are rather simple. The new top level menu looks like:

Opt: 1 = Input 2 = Anal 3 = Output 4 = File 5 = Quit

and the file level menu is:

Opt: 0 = Top 1 = B/D 2 = Grey 3 = Target

Note that the QUIT selection in the top level menu changes to 5 to make a sensible space for the file operations.

This is a good time to do some checks. After saving the program, type in lines 500, 600, and 800 with a simple print statement and a return statement to show which target you have accessed. Now run the program and exercise the menu selections. It isn't necessary to save the program here unless you have to make corrections.

Figure 5 gives the code to accomplish the file-based functions. Insert these lines into the big hole of program line numbers preceding the hourly MUF driver at line 1000. The space provided in the original PATHFINDER coding ended up being a little too tight to maintain MODULO 10 line numbering (particularly in the grey-line list section) but, with a little squeezing of line numbers, the code fits. The function of this code is broken down into three main subroutines. Lines 500-570 generate the bearing/distance report summary; line 580 is a subroutine which is called to print the bearing and distance. The code from lines 600-780 does the grey-line summary and calls the subroutine in lines 720-760 to print a line. If the location is on *your grey line, this subroutine calls another* at line 770 to print the time and condition of the target grey line. The routine to search for a location in the data file is in lines 800-940.

The finished product

You'll have a fairly sophisticated operating aid after making all these modifications to PATHFINDER. Anything comparable costs a lot more than two copies of *HAM RADIO*, and chances are the MUF algorithm isn't as good and doesn't run as fast. PATHFINDER can do a lot for almost any Amateur who has his own hf equipment. I recently discovered one application in the field of antipodal DX.[5] After entering the date and solar flux, execute a radial MUF projection with a path-length hop value of 5 and any hour you choose. The radial report will show you the MUF for each bearing to your antipode.

Try those bearings which show a MUF near the band you intend to work.

In the global modes PATHFINDER accesses the data file one location at a time and uses these locations as the target for any computation required. The bearing/distance reports are printed for each location while the grey-line summary includes only those locations which have a grey line within 45 minutes of one of your grey lines. Since the grey-line summary already takes a lot of time, there's no suggested MUF for this report. If you're interested in the MUF for a particular grey-line path, run the point-to-point MUF for that location.

You can achieve expanded utility of the file-based features by generating several data files, based on your own operating habits, and queue for a file name to use in generating the summary reports. Your summaries would take less time because they would be accessing fewer locations in your data file. For instance, you could delete all the domestic locations or all the locations that could never have a common terminator from the grey-line file you use.

Another suggestion is to make several data files based on continent or region of the world and select the one which interests you at the time. There is nothing magical about the prefix value in the data files. You might want to enter the state or country name in this field rather than a prefix. These tactics would be particularly beneficial if you use the grey-line summary frequently or want to separate bearing/distance reports for each region. Just remember that you'll have to load the key array corresponding to the data file selected.

Sorts can become complicated and, with the amount of storage a sort might require, I decided to avoid this nicety in PATHFINDER. You are welcome to implement your own to get your grey-line report in a time sequential format. If you wish to convert the data file to a random access file, note that the key array and key file offer an open door to a significant improvement in performance and expanded utility. A revision of the grey-line test ranges is another customization you may want to consider for your copy of the program. You can do this by modifying the constant (.75) in the statements on lines 630 of **fig. 5**. This value is a decimal hour representation of the half-width of the grey-line range. Changing these constants to .5 would give a ±30-minute tolerance for grey-line reporting. There's no reason to keep the test ranges symmetrical or even equal. You might benefit by skewing these tests to reflect your own preferences or station capabilities.

Once you start modifying PATHFINDER to suit your preferences, you'll appreciate the structured form of its code. There are lots of little program blocks defined as subroutines which are executed by the main program or by other subroutines. There might be a little more code required to do some functions than with a GOTO, but

FIGURE 6

```
PATHFINDER menu prompts and their functions

TOP menu:
Opt: 1=Input 2=Anal 3=Output 4=File 5=Quit

  1  goto set INPUT menu
  2  goto select ANALYSIS menu
  3  goto select OUTPUT menu
  4  goto select FILE fuction menu
  5  QUIT the program


set INPUT menu:
Opt: 0=Top 1=Date 2=Flux 3=SSN 4=Target 5=Home

  0  return to TOP level menu
  1  change the DATE
  2  change the solar FLUX
  3  change the SUNSPOT NUMBER
  4  change the TARGET coordinates
  5  change the HOME coordinates


ANALYSIS select menu:
Opt: 0=Top 1=B/D 2=Grey 3=MUF

  0  return to TOP level menu
  1  report path BEARING and DISTANCE
  2  report the endpoint GREY-LINE conditions
  3  goto the MUF selection menu


MUF selection menu:
Opt: 0=Top 1=Short 2=Long 3=Radial

  0  return to TOP level menu
  1  project SHORT path hourly muf
  2  project LONG path hourly muf
  3  project RADIAL muf


FILE function select menu:
Opt: 0=Top 1=B/D 2=Grey 3=Target

  0  return to TOP level menu
  1  print global BEARING and DISTANCE report
  2  print global GREY-LINE condition report
  3  load TARGET location from file
```

PATHFINDER menu prompts and their functions.

FIGURE 7

```
PATHFINDER data prompts

PREFIX TO SEARCH FOR
   enter a prefix to find for a new target

<CR> if OK, N for NEXT, else to QUIT
   enter:  a carriage return to accept this location
           "N" to reject this location and see others
           any other character returns to TOP level menu

What GMT hour for display
   enter the time for a radial projection
     (decimal hours)

1 Hop = 2488 mi (4000 Km). Long Path beyond 5
How many hops for display (0.1 to 9.9)
   enter number of hops to use for radial path length
     (decimal values ok)

Month number
   enter the month number (1 to 12)

Day of month
   enter the day of the month (1 to 28, 30 or 31)

Solar Flux (64 to 301)
   enter a value for solar flux

Sun Spot Number (0 to 250)
   enter a value for sunspot number

Target Latitude (- south, 89.9 max)
   enter the target latitude in decimal degrees and then

Target Longitude (- east)
   enter the target longitude in decimal degrees

Home Latitude (- south, 89.9 max)
   enter the home latitude in decimal degrees and then

Home Longitude (- east)
   enter the home longitude in decimal degrees
```

PATHFINDER data prompts.

FIGURE 8

```
PATHFINDER messages

    Welcome to PATHFINDER-85
COPYRIGHT 1987 by Ronald C. Todd

     PATHFINDER login and copyright message


ERROR
     error message, occurs for several situations


Found: XYZ in Lower Hattiap
     requested prefix found


NOT Found
     requested prefix not found
```

PATHFINDER messages.

FIGURE 9

```
GENDAT menu and data prompts

GENDAT MENU:
 Opt: 1=Add 2=Edit 3=Insert 4=Delete 5=New 6=EXIT
    1 ADD records to end of file
    2 EDIT an existing record
    3 INSERT records in middle of file
    4 DELETE an existing record
    5 initialize a NEW data file
    6 generate the key file and EXIT the program

 <CR> to Continue, else Done
    enter a carriage return to continue with function,
    otherwise return to menu

 EDIT PREFIX:
    enter the prefix you wish to edit

 ADD AFTER PREFIX:
    enter the prefix you wish to insert records after

 DELETE PREFIX:
    enter the prefix you wish to delete

 D to Delete, else Reject
    enter a "D" if you really want to delete this record

 Prifix
    enter the record prefix

 QTH
    enter the record location name

 Latitude
    enter the record latitude in decimal degrees

 Longitude
    enter the record longitude in decimal degrees

 <CR> if OK, R to Redo, else QUIT
    enter a carriage return to accept input data
          an "R" to redo the input data
          otherwise return to function

 <CR> if OK, N for NEXT, else to QUIT; BS
    enter a carriage return to accept record found
          an "N" to look for next occurence of same prefix
          otherwise quit the search and function
```

GENDAT menu and data prompts.

FIGURE 10

```
GENDAT messages

!... PLEASE CHECK DATA ...!
   check input data before writing to file

END of FILE
   end of file message

Found: KY1 in Lower Hattrap Lat= 45 Lon=-50
   display of requested record found
```

GENDAT messages.

the partitioning of tasks in this manner means that debugging is easier and utility will be greater. I strongly suggest that you retain this design for your own revisions.

les Menus

Some of the original PATHFINDER users asked me to explain the menu functions. In **fig. 6** you'll find a display of each of the menu prompts, along with a brief explanation of the function of each selection. A summary of the data prompts PATHFINDER uses is given in **fig. 7** along with a description of what each means and, where significant, the data type expected. In fig. 8, you'll find the messages and a description of their meanings. **Figures 9** and **10** give the menu functions, data prompts and messages for GENDAT. I'll be glad to answer all requests for more information accompanied by an SASE.

One other shortcoming of PATHFINDER, alluded to briefly in my original article, is error trapping. To keep the program to a reasonably publishable size, error trapping on most inputs has been minimized. This may generate some problems upon entering polar coordinates for one or both of the path end points. The solution in this case is to limit all latitudes to a magnitude of 89.99; this will be sufficiently close (0.69 miles from a pole) for most applications. In most instances, the likelihood of divide by zero and out-of-range errors have been minimized through the use of suitable decision gates in the algorithms. If you do find situations that generate errors not trapped by the code, please forward these to me. I'll be glad to report them along with suggested code revisions. If there's sufficient interest, I might be talked into organizing a PATHFINDER user's group dedicated to maintaining and supporting the program.

Watch your language

All listings in this article are presented in Microsoft Extended Basic-80®, for a CP/M® operating system. This is a powerful and rather universal programming language, but it may have some features and syntax not shared with other BASIC dialects. Some of the constructs and statements which might not be included or may work differently in your BASIC are the DIM, DEFINT, ELSE, RESTORE, and ON GOTO/GOSUB. Your printer and disk access functions may require different approaches, but in general can be easily converted.

Several dialects of BASIC do not implement the ELSE clause for an IF/THEN construct; in that case you should place the statements executed by the ELSE condition on an intermediate line and then replace the ELSE with a GOTO branch past the intermediate line which contains the operations called for by the ELSE in this program. I normally increase the line number of the intermediate line by 5 from the source line when this is necessary. In summarizing conversions, it's best to keep your BASIC manual handy and refer to it whenever you have a question.

This version of PATHFINDER has been submitted to the ARRL Program Exchange. I would appreciate any suggestions you have for upgrades and further extensions to the program.

Thanks to all who have helped make PATHFINDER a viable reality by offering their comments and critiques.

For more updates to PATHFINDER see page 58. *Ed.*

references

1. Ron Todd, K3FR, "PATHFINDER: Improved MINIMUF Program," *ham radio*, May 1988, page 26.
2. R.B. Rose, "MINIMUF: A Simplified MUF Prediction Program for Microcomputers," *QST*, December 1982, pages 36-38.
3. G. Hall, ed., *ARRL Antenna Book*, 14th edition, American Radio Relay League, Newington, Connecticut 1982.
4. Wayne Overbeck and J.A. Steffen, *Computer Programs for Amateur Radio*, Hayden Book Company, Hasbrouck Heights, New Jersey, 1984.
5. Garth Stonehocker, KØRYW, "DX Forecaster," *ham radio*, March 1988, pages 78-80.

Answers to some common questions about PATHFINDER

Line 1200: The back slash "\" is the integer division operator. It is used to assure an integer index for the array MOUT(). If your language does not support this feature then force the result of a normal division via the INT function: MOUT(INT(A0/10))=J9.

Line 3420: This is recursive code, not an infinite loop. The line serves to force all computed longitudes into the range $-180 <= LON <= 180$. If the LON is outside the range, then 360 degrees (P1) is added or subtracted and the test repeated. When the LON is in range, execution passes on to line 3430.

Lines 8300 and 8320: These lines were referenced in the text of the article and several have found that 8320 does not exist in the listing, while 8300 is actually the start of the SSN input routine. This mixup is in the article text and not in the listing. The text should refer to lines 8400 and 8420 respectively.

Lines 300, 1040, 1160, and 1170: The STEP option on the FOR loops is a way of controlling both the increment value and the maximum iterations of the loop. The test and increment values for the loop control variable are set up to provide two MUF values per output line.

Updates to PATHFINDER release 1.10

Incorporate the following changes into your program as well as making the changes noted in the grey-line enhancements in fig.2 of PATHFINDER-Part 2.

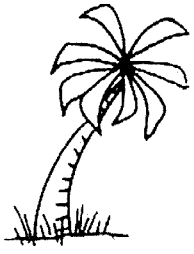
```
30 'MICROSOFT BASIC version, Release 1.15, 5/12/88
2040 IF K9(I)>23.99 THEN 2100 ELSE IF SS(I)<SR(I) THEN 2060
4020 M9=1+2.5*M9*SQR(M9): IK=INT(G1/P5)+1: L=1/(2*IK)
```

These revisions will correct some PATHFINDER problems. Here is a new proof simulation which, if everything matches within 1.0 MHz, will demonstrate correct function.

Date is: Dec 21
Solar flux = 150.0 Sunspot number = 104
Home QTH: Lat = −87.0 Lon = 130.0
Target QTH: Lat = 80.0 Lon = −50.0
Path bearing = 0 degrees
Path length = 12920 miles

LONG PATH

GMT	MUF	GMT	MUF	GMT	MUF	GMT	MUF
0.00	23.57	6.00	13.96	12.00	12.95	18.00	24.98
1.00	23.36	7.00	14.14	13.00	11.68	19.00	24.74
2.00	21.15	8.00	13.18	14.00	11.04	20.00	24.51
3.00	16.62	9.00	13.29	15.00	11.45	21.00	24.28
4.00	14.86	10.00	13.85	16.00	25.49	22.00	24.04
5.00	14.17	11.00	13.10	17.00	25.22	23.00	23.80



29th ANNUAL

TROPICAL HAMBOREE

A.R.R.L. FLORIDA STATE CONVENTION

FEBRUARY 4-5, 1989

TAMIAMI PARK FAIR GROUNDS
10901 S.W. 24th Street (Coral Way), Miami, Florida
HOURS: 9 A.M.-5 P.M. SATURDAY • 9 A.M.-4 P.M. SUNDAY

FREE PARKING 15,000 VEHICLES •
1,000 INDOOR SWAP TABLES •
300 CAMPSITES WITH FULL HOOKUPS •

- **200 COMMERCIAL EXHIBIT BOOTHS**
- **COMPUTERS & SOFTWARE**
- **LICENSE EXAMS**

Registration: $5.00 Advance — $6.00 Door. Valid Both Days. (Advance deadline January 30th.)
Swap Tables, 2 Days: $16.00 each. Power: $10.00 per User.
All swap table holders must have registration ticket.
Campsites: $12.00 per Day • Includes Water, Power, Sanitary Hookups & Showers.
(All RV vehicles, tent campers, vans, trailers welcome — no ground tents, please.)

Make Checks for Registration, Swap Tables & Campsites Payable to:
Dade Radio Club & Mail As Follows:

Tickets & Hotel Info Only: Evelyn Gauzens, W4WYR, 2780 N.W. 3rd St., Miami, FL 33125
Swap Tables, RV, Tickets & Hotel: John Hall, WD4SFG, 8670 S.W. 29th St., Miami, FL 33155
RV & Tickets Only: Dick Leisy, W4OOH, 650 W. 63rd Dr., Hialeah, FL 33012
Exhibit Booth & General Info: Evelyn Gauzens (address above) or Call (305) 642-4139 or (305) 233-0000

(BROCHURE WITH FULL DETAILS AVAILABLE DECEMBER 1st)

EFFICIENTLY LAUNCH VHF/UHF WAVE

By Hal Silverman, W3HWC, 14004 Prospect Avenue, Mt. Airy, Maryland 21771

Simple geometry determines impedance match device

The Amateur bands below 30 MHz are becoming crowded; consequently, many operators are moving to the VHF/UHF spectrum.

With higher frequencies come shorter wavelengths, distributed components, and shorter antennas. Shorter wavelengths allow for easier impedance matching between the transmission line and the antenna, or between two transmission lines of different impedances.

In the mid-fifties an article about a device called a G-line appeared in *Radio and Television News*. It consisted of a single hard-wire line with launchers to match impedances at each end. The G-line never became very popular, but the launcher has some nice qualities at higher frequencies. It looks like a funnel and works on the same principle as coaxial cable.

The impedance of coax is found by the ratio of the center conductor diameter to the inside diameter of the shield, using the following formula that disregards the dielectric:

$$Z = 138 \text{ Log } (D2/D1) \quad (1)$$

Where D2 is the inside diameter of the shield and D1 is the outside diameter of the center conductor.

By changing the ratio of D1 to D2 you change the impedance of the transmission line. If the transmission line impedance changes gradually, say over a quarter wavelength, the transition won't create a standing wave sufficient to cause appreciable loss. In short, you can match two impedances with minimum loss. This same concept is used in the G-line launcher.

The wavelength at 450 MHz is 66.66 cm, just 2/3 of a meter. A quarter wave length is only 16 cm. This short wavelength allows you to use the distributed components of coax to make an impedance transformer that will serve for any frequency within that Amateur band.

For example, if you have a helix antenna and a length of 50-ohm coax cable, the input impedance of the helix is approximately 140 ohms. The mismatch that would accompany a direct connection would cancel out the antenna's gain. If you choose to use a quarter-wavelength coaxial transformer for matching, it would need a characteristic impedance of:

$$Z = \sqrt{(Z1 \times Z2)}$$
$$= \sqrt{(50 \times 140)}$$
$$= 83.66 \text{ ohms}$$

which is not a standard value. By using a launcher, you can effect a more efficient match between the cable and the helix.

The launcher dimensions include the input diameter, output diameter, and length. The length is not critical — but it should be longer than a quarter wavelength at the lowest frequency of operation. The two diameters are a function of the impedances.

The input diameter, for a 50-ohm cable is found as follows:

$Z_{in} = 138 \text{ Log } (D2/D1)$
Let D1 = 1
Then 50 = 138 Log D2
2.303 = D2

The narrow end of the cone is 2-1/3 times larger than the wire of the helix antenna or the center conductor of the cable.

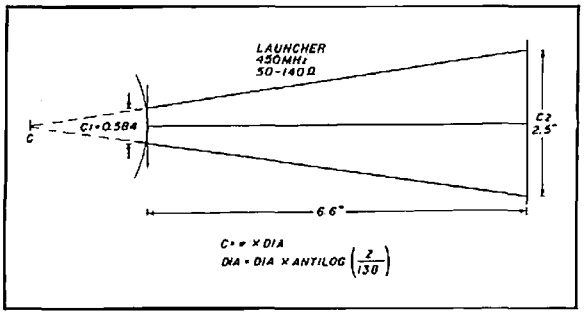
The output diameter of the cone for a 140-ohm antenna is as follows:

$Z_{out} = 138 \text{ Log } (D3/D1)$
Let D1 = 1
Then 140 = 138 Log D3
10.33 = D3

The wide end of the cone is 10-1/3 times the wire of the helix antenna or the center conductor of the cable.

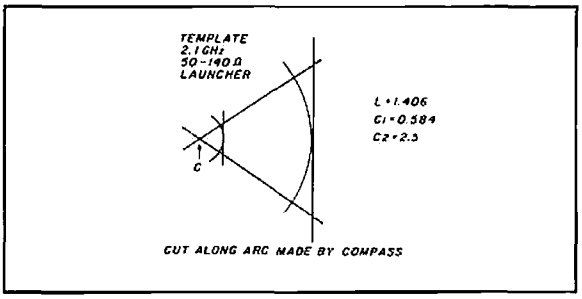
Use the information above to construct the launcher. First draw a template as shown in fig. 1. I used No. 12 AWG wire (*diameter* = 0.08081 inches) for D1. Cut along the curved lines and roll it onto itself to form the cone. If you have a compass with a 9-inch span, scribe

FIGURE 1



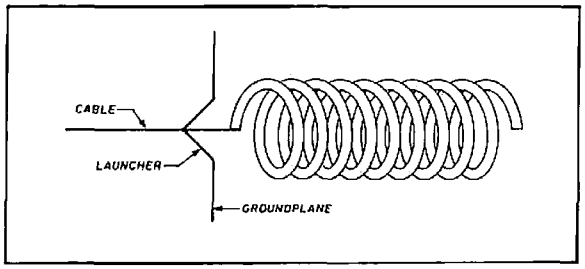
450-MHz roll-your-own launcher template.

FIGURE 2



Template for 2.1 GHz 50-140 launcher. Cut along arc made by compass.

FIGURE 3



Helix antenna with launcher.

both ends as I did in the 2.1-GHz version in **fig. 2.** It will give the cone sides of equal length.

Purists will argue that the cone should be logarithmic like an old automobile horn. But you're working at the narrow end of the horn, and at that point the lines are almost straight.

One additional thing: if you're building a helix, the launcher diameter must be smaller than the helix diameter or the ground plane will fail. **Figure 3** shows the helix with launcher attached to the ground plane.

To test the idea, I built a helix antenna for 2.1 GHz and attached the launcher at the feedpoint. Return loss measurements of 18 dB indicate the antenna system works well.

Article F **HAM RADIO**

RELY ON JAN FOR 3-WAY HELP:

1. TECHNICALLY CORRECT CRYSTALS TO YOUR SPECS.
2. QUICK TURNAROUND WITH HUGE INVENTORY, PROMPT SERVICE, AND OUR EMERGENCY ORDER PLAN.
3. LOW PRICES. ✓ 139

QUARTZ CRYSTALS FOR TWO-WAY — INDUSTRY MARINE — AMATEURS SCANNERS — CBs MICROPROCESSORS

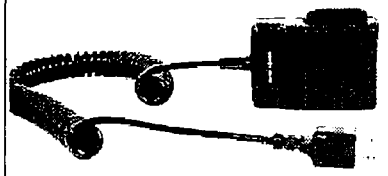
JAN CRYSTALS
SINCE 1965

FOR FREE CATALOG, CALL OR WRITE:
JAN CRYSTALS
RO. BOX 06017
FORT MYERS, FL 33906
(813) 936-2397

VISA MasterCard

TOLL-FREE: 1-800-237-3063
IN FLORIDA: 1-800-226-XTAL
FAX ORDERS: 1-813-936-3750

NOVEX Speaker Mics

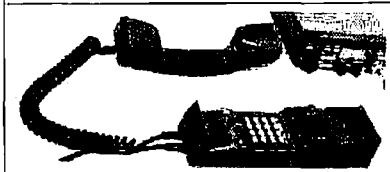


High quality audio • Privacy earphone jack
Rotatable lapel clip • Hi-Lo volume switch

ICOM DMC 537I
Kenwood DMC 537K
Yaesu DMC 537Y

SUPER VALUE
only $19.95
$4 Shipping & handling

NOVEX Handsets



PTT handset • backlit OTMF • Private listening
Wired for most current ICOM, Kenwood, Yaesu & others (on special request)

ICOM HCS701I, Kenwood HCS701K, Yaesu HCS701Y
Available for many other radios at slightly higher prices

Introductory price $79.95
✓ 140 $4 shipping & handling

EEB
Orders: 800-368-3270 Local & tech info 703-938-3350
Electronic Equipment Bank
5161 Mill St. NE, Vienna, VA 22180
(just minutes from Washington, DC)

MOVING?
KEEP HAM RADIO COMING...

If possible let us know four to six weeks before you move and we will make sure your HAM RADIO Magazine arrives on schedule. Just remove the mailing label from this magazine and affix below. Then complete your new address (or any other corrections) in the space provided and we'll take care of the rest.

ham radio Magazine
Greenville, NH 03048

Allow 4-6 weeks for correction.

Thanks for helping us to serve you better.

Here's my new address:
Call
Name
Address
City
State
Zip

AFFIX LABEL HERE



THE WEEKENDER

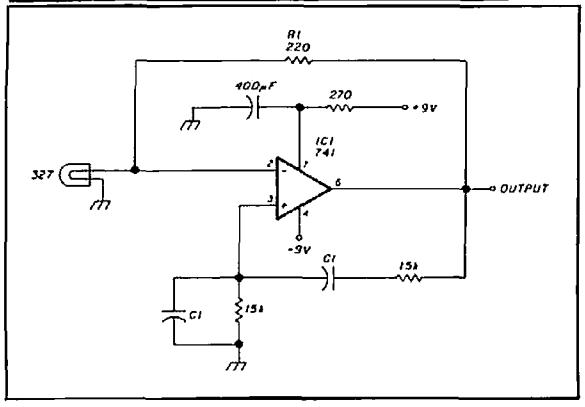
A CODE PRACTICE OSCILLATOR

Many code practice circuits have been published. Most will do an acceptable job, but tend to have a very rough "buzz saw" tone. They don't sound anything like a CW signal received off the air. This code practice oscillator has a pure sine wave 800-Hz note. It's a joy to use.

Circuit details

To obtain a pure tone, I used an audio oscillator that generates a sine wave with low distortion. In the circuit[1] in **fig. 1**, an incandescent lamp-type 327, 28 volts at 40mA controls the feedback to the inverting input of a 741 operational amplifier. It regulates the signal amplitude to 5 volts peak-to-peak. The lamp glows brighter if the amplitude rises, increasing its resistance. The voltage divider consists of the 220-ohm feedback resistor (R1) and lamp. It feeds back a higher proportion of the signal to the inverting input decreasing the closed loop gain. The amplitude decreases and is regulated. In normal operation the lamp's light will be invisible. Active devices in the op-amp are operated in the linear region yielding a single-tone sine wave.

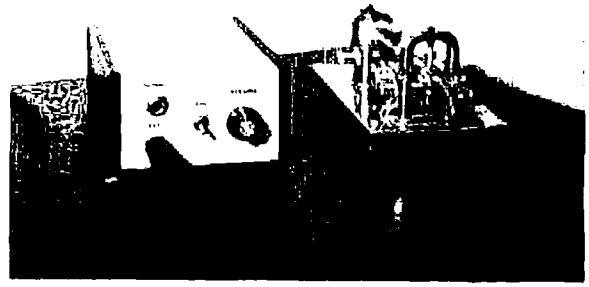
FIGURE 1



Oscillator circuit.

By John Pivnichny, N2DCH, 3824 Pembrooke Lane, Vestal, New York 13850

PHOTO A



A code practice oscillator.

Parts List

Resistors (1/4 watt)
1 22k
1 1k
1 1M
2 220
1 470Ω
1 4k
1 39
1 10
1 270
2 15k

Potentiometers
1 10k audio taper

ICs
1 LM386 (Radio Shack no. 276-1731)
1 MC3340A/ECG1829
1 LM741 (Radio Shack no. 276-1601)

Miscellaneous
2 9v Battery
2 Phone jack
2 Battery connector
1 DPST switch
1 3" speaker
1 Enclosure (Ten Tec JG-3) 4" x 2-1/4" x 6"
3 (optional) 8 pin DIP socket
Perf board (Radio Shack)
Fuse clip (Radio Shack)

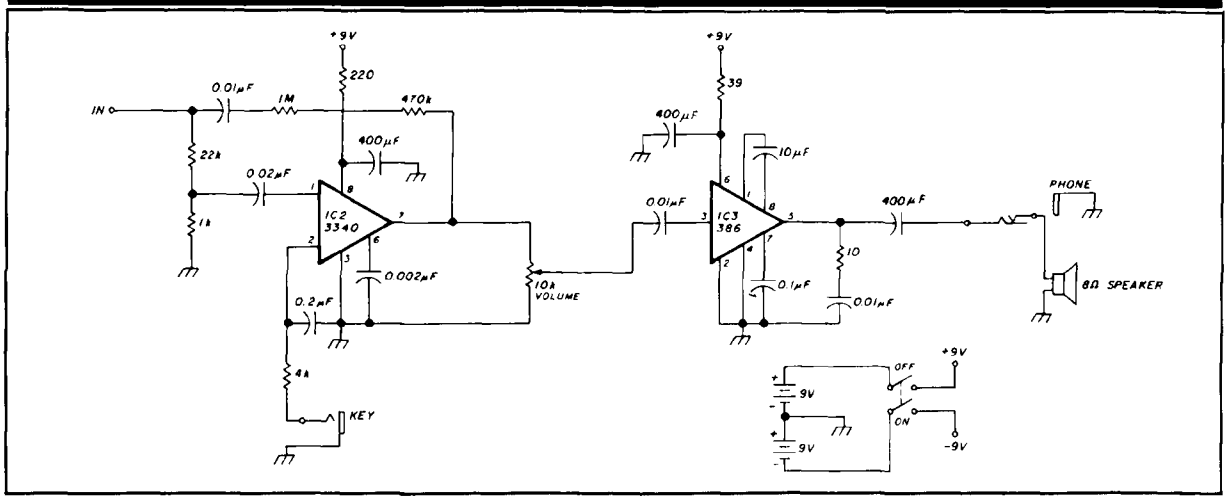
Capacitors
4 400μF (electrolytic)
1 10μF (tantalum)
3 .01μF (disc)
1 1μF (disc)
1 2μF (disc)
1 .02μF (disc)
1 .002μF (disc)

Other audio amplifier circuits drive into saturation to regulate the amplitude. This causes the sine wave to be "squared off", generating distortion. Circuits using the 555 timer IC produce true square waves and have particularly raspy tones.

Oscillation frequency is controlled by the dual RC network in the noninverting feedback loop. Two 15k resistors and capacitors (C1), made up of three 4700 pF and one 680 pF disc ceramic capacitor, set an 800-Hz tone. These values can be changed to suit your preference. The resistors and capacitor *don't* have to be matched.

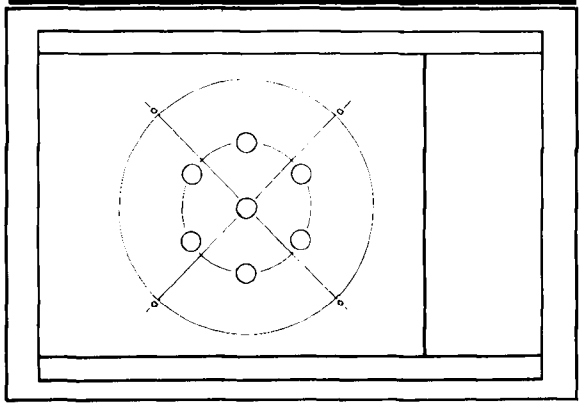
Keying the circuit in **fig. 1** through the power leads is *not* recommended. A chirp would be produced as the lamp comes up to temperature. Let the oscillator run continuously and key its output signal with the electronic attenuator, IC2 (Motorola part MC3340P — also available as ECG829), in **fig. 2**. A key in the gain control input does a nice job. Shaping is controlled by the 4k and 0.2 μF RC time constant; during key up

FIGURE 2



Keying circuit and power amplifier.

FIGURE 3



Top cover.

this part provides 60-80 dB attenuation. This may not be enough to completely eliminate a backwave signal. A feed-forward path using a 0.01 μF capacitor, 1 meg resistor, and a 470k resistor in series cancels any residual backwave signal. Note that the signal going through IC2 is inverted while the feed-forward signal is not; the two cancel out during key up. During key down IC2 provides 13-dB gain and can accept a maximum of 0.5 volt peak-to-peak signal at its input (pin 1). The resistive voltage divider at its input decreases the oscillator amplitude to an acceptable level.

Power amplifier IC3 is a conventional 386 circuit.[2,3] There is enough power gain to drive headphones or a small speaker. **Figure 2** shows the keyer and audio amplifier circuits. Two 9-volt transistor radio batteries supply power. The positive supply is decoupled at each IC. (This may be unnecessary as all circuits are very stable.)

Construction

All components are mounted on a 1-3/4″ × 3″ piece of perfboard. The lamp is mounted with a single fuse clip connecting it to the outside of the base, and a No. 30 gauge wire is soldered to the base center contact. The two batteries are held in place with spring clips fastened to the bottom of the enclosure with 4-40 × 1/4″ machine screws. All other components are attached to the circuit board by their leads. I used insulated No. 30 gauge wire for the interconnections.

The box is 4″ × 2-1/4″ × 6″ with a gray finish and black plastic side panels. A 3″ diameter speaker is fastened to the top cover. Seven 1/4″ holes, drilled as shown in fig. 3, form a speaker grill. There are also four 1/16″ holes for speaker mounting machine screws. The front panel holds two 1/4″ phone jacks for the key and earphone plugs, a DPST power switch, and the volume control. Dry transfer lettering with a protective coat of clear shellac completes the job. See the photograph for details.

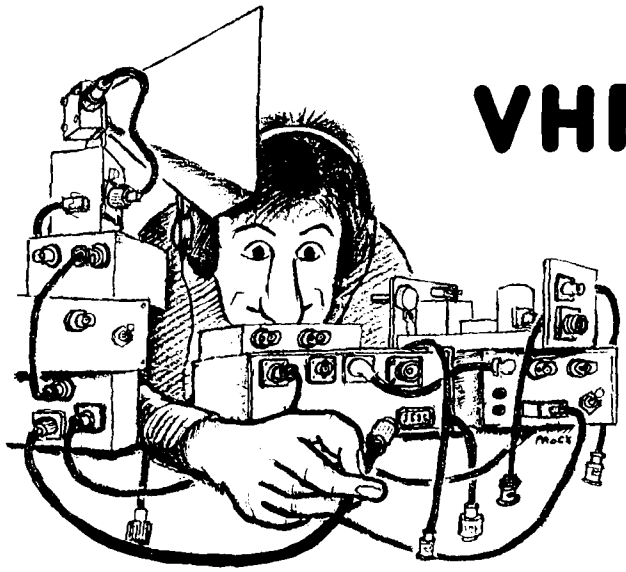
Operation

Keying is done with a hand key, keyer, or semi-automatic bug. The built-in speaker and batteries make this oscillator compact, easy to use, and portable. Why not build one up for your next project?

References

1. Tom Schultz, "Audio Oscillator," *QST*, "Hints and Kinks," November 1974, page 43.
2. Rick Littlefield, K1BQT, "Construct an Audio Amplifier...," *QST*, April 1983, pages 28-31.
3. J. Rusgrove, "A General Purpose Audio Amplifier," *QST*, November 1976, page 32.

Article G **HAM RADIO**



VHF/UHF WORLD

Joe Reisert, W1JR

IMD and splatter

Interference has always been one of the greatest impediments to communications, regardless of frequency. If an Amateur with a strong signal *transmits* right on a frequency where a weak signal is present, there is virtually no way you can copy the weaker signal unless the stronger station stops transmitting.

But, interference isn't confined to the simple case described above. Often there are other circumstances like IMD (intermodulation distortion) — often referred to as splatter on SSB. The latter may be transmitted, or locally generated in the receiver.

This month I'll review the subject of IMD/splatter, answer some of the most often asked questions, and discuss some recommendations and test methods.

CW transmission

Using CW provides a partial solution *to the interference problem. Even* if two signals are on exactly the same frequency, you can achieve partial copy of the weak signal when the strong signal is "key up." Also, if a weak signal is on a slightly different frequency from a strong one (perhaps as little as 1.0 kHz away), and the strong signal is not blocking your receiver, you may be able to separate the signals if you have a good narrowband i-f filter (typically 500-Hz bandwidth) in your receiver.

There is a very basic reason why CW signals can be so easily separated. A good clean CW signal occupies very little bandwidth — less than 500 Hz, as shown in **fig. 1A**. This is only true if the oscillator in the transmitter is very stable and doesn't have any "phase noise."

Phase noise is a form of frequency modulation that is often superimposed on the carrier frequency. As a result, a transmitted signal is broadened or spread out in frequency (see **fig. 1B**). This phenomenon is particularly evident in the modern-day synthesized transceivers. I often refer to phase noise as the "aurora" affect. If you tune a few kilohertz off the carrier of a CW signal with phase noise, it sounds like keyed white noise which is similar to the signal returning from the auroral reflection.

Further complicating this phenomenon is that the local oscillator in your receiver may also have phase noise, exacerbating the problem. It will be difficult, if not impossible, to determine whether the transmitter or the receiver, or both, are the culprits! For those who want more information on this communications bugaboo, I'd recommend reading reference 1.

SSB transmission

As if the problems of CW transmission weren't bad enough, enter an SSB transmitter and you have a whole new ballgame. By nature an SSB signal has a broad bandwidth, typically 2-3 kHz at the half-power point, when carrying voice intelligence.

In the good old days, SSB signals were generated by the phasing method *because* it was low cost and had good fidelity. Phasing exciters characteristically have wider bandwidth because the filtering and phasing required is more complex.

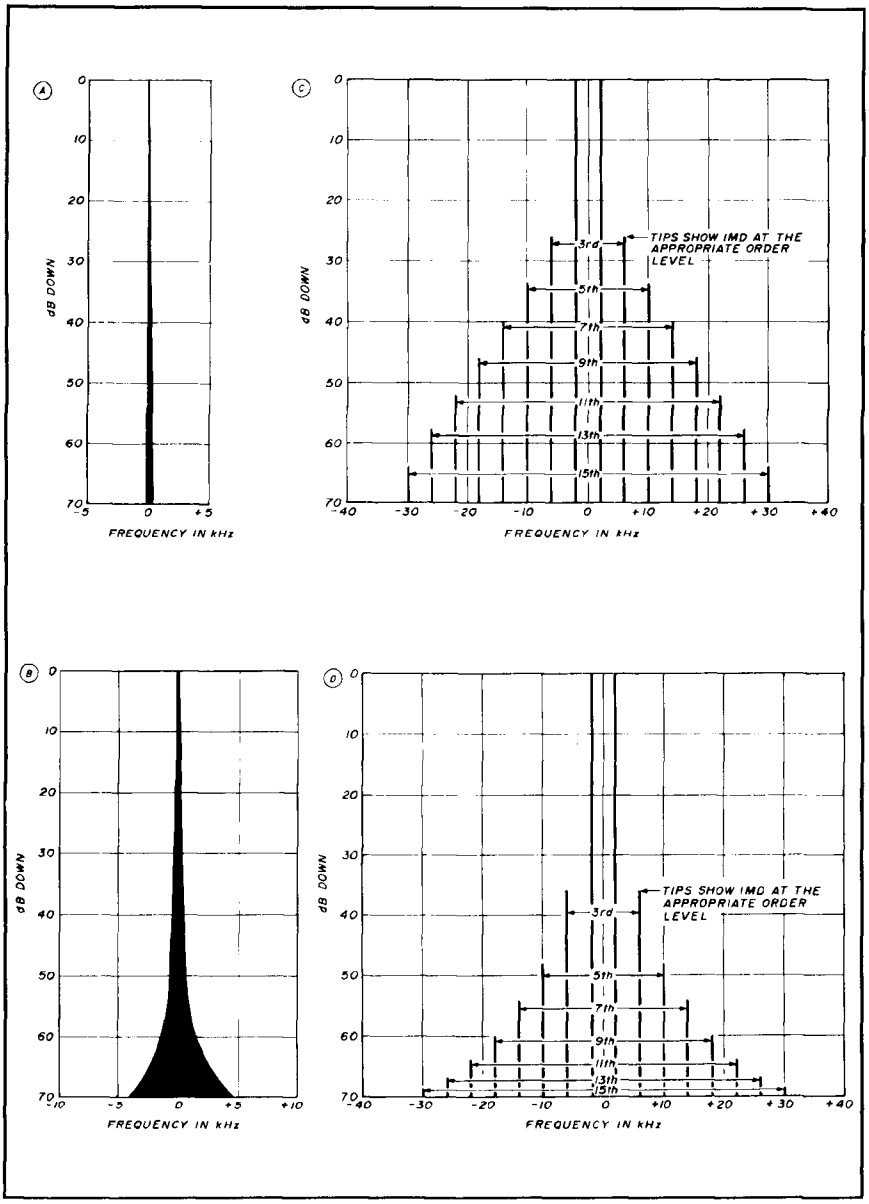
Most modern exciters generate SSB by the rf-filtering method which employs well-controlled crystal bandpass filters. However, even these filters are seldom specified over more than a 40-dB range.

The local VHF/UHFers can tell when I alternate between my phasing and filter SSB exciters. The phasing exciter has good audio fidelity, but the IMD outside the passband is at a higher level. The filter exciter has poorer audio fidelity, but outside the passband IMD drops off at a faster rate.

What most Amateurs tend to forget is that SSB signals, by their very nature, have "controlled" IMD. Amateur SSB exciters and power amplifiers are often specified to have a typical IMD specification — 26-30 dB at a specific PEP output level. This means that the third order IMD products (the ones generated closest to the desired signal but outside the 2.5-3 kHz passband), are only 26-30 dB below the peak power level specified. Higher order sidebands are also present, but usually at a lower level.

Figure 1C puts all this in perspec-

FIGURE 1



(A) The output spectrum of a pure CW signal.
(B) The output spectrum of a typical CW signal with phase noise.
(C) The output spectrum of a clean SSB signal from a commercial amplifier.
(D) A typical Amateur SSB transmitter.

tive. It shows the typical output spectrum from a "commercial quality" filter-type SSB transmitter when modulated by two identical level audio tones, one near 500 and the other near 2500 Hz (adapted from reference 2). *Remember that this spectrum display is typcially 6-10 dB better than the average Amateur transmitter.*

Referring to fig. 1C, note the high level of rf at the 3rd order level — typically 36-dB down. Consequently, there will be rf energy outside the normal 2-3 kHz passband that will be only 36-dB below the carrier peaks, or about one four-thousandth of the peak power. Not bad if the station is only 25-30 dB out of the noise, but very objectionable if it's 40-60 dB out of the noise.

What about the higher order sidebands? The 5th, 7th, and 9th order IMD products are still only down 48-60 dB. They will be very noticeable on a strong local station which is typically 60-80 dB out of the noise!

To the average HFer, these problems may be an annoyance. With heavy interference, local noise, and intermittent operation (like a "DX pileup") you can learn to "live with it." However, to the VHF/UHFer who often listens on a relatively quiet band over a limited frequency range, IMD can be difficult to tolerate.

SSB splatter

So far I've been talking about the idealized transmitter case. What's it like when the IMD levels of an SSB transmitter are at Amateur specifications? Worse yet, what happens when an Amateur is trying to "eek out" the last bit of transmitted power by shouting into the microphone or turning the gain control up too high?

Figure 1D shows one possible spectrum display. This is a typical Amateur transmitter output spectrum at rated power output. Note that the 3rd order IMD products are only 26-dB below the peak power level. Furthermore, the 9th order products are 46-dB down, 14-dB worse than the commercial transmitter! Remember that if the transmitter is driven above these levels, the IMD will increase dramatically.

Why is this true? The linearity of a transmitter is limited by the ability of each stage to accurately reproduce and amplify the input signal. Each stage, usually a vacuum tube or solid state device, has a finite output power level beyond which it will generate distortion. Exceeding this level results in high levels of IMD and splatter.

Transmitting devices

Let's compare some typical transmitting devices. Vacuum tubes have been around a long time and maintain a good reputation when used as rf power amplifiers. RF transistors are in wide use, although they are often

TABLE 1

This table shows some of the most popular VHF/UHF high power transmitting tubes used by Amateurs. The ratings are extracted from manufacturers' data sheets. See text for further explanation.

Tube type	Dissipation in watts	Peak envelope power output	IMD specs	Remarks
Triodes				
3CX400A7/8874	400	590	35	
3-400Z/8163	400	590	28	
3CX800A7	800	750	36	
3-1000Z/8164	1000	1080	29	
3CX1500A7/8877	1500	2000	38	
8938	1500	2000	44	
Tetrodes				
4CX250R/7580W	250	470	23	
8930	350	350	27	Formerly DX393
7650	600	680	31	
4-1000/8166	1000	1540	NA	IMD Estimate 25 dB
4CX1000A/8168	1000	1400	23	
7213	1500	1000	NA	IMD Estimate 25 dB
4CX1500B/8660	1500	1500	43	

NA: Not available

unfairly targeted as "splatter generators." More on this shortly.

Operating each stage of a transmitter in class "A" would be ideal for linear operation, but the power consumption would increase. The power dissipation of each stage would also be high, making the cost of the appropriate high power amplifier devices prohibitive. On the other hand, operating each transmitting stage in class "C" would raise efficiency, but distortion would be prohibitive.

As a result, most vacuum tube amplifiers are operated in class "AB" with moderate idling current. Vacuum tubes are usually large and, if they can't dissipate heat easily by themselves, heat dissipation can be assisted by a fan or blower.

Cooling solid-state devices with their very small geometry is still a problem, but one that is improving. Large heat sinks and special compounds are used to thermally bond the devices to the heat sink. Also most solid-state devices are operated in class "B." However, they are more prone to distortion.

Another reason vacuum tubes are so linear is that they operate with high voltages on the anode. Consequently, there is a large voltage difference between the typical operating voltage on the anode and the minimum voltage across the anode when saturation occurs. If you go back to old vacuum tube literature you'll find lots of discussion about "load lines." In the typical vacuum tube application the load line operates over a very wide voltage swing before saturation and distortion occurs. Furthermore, vacuum tubes usually operate with output impedance levels of 1-5,000 ohms. This is a moderately easy impedance to match to 50 ohms; it's often done with a pi-network. As a result, impedance matching losses are usually low and efficiency is high.

Contrast this with the typical solid-state power amplifier used by Amateurs. It most often uses transistors specified for 12-14 volt operation because this is the voltage usually used in mobile operation, and therefore in Amateur shacks. These devices typically saturate at 1-2 volts, so the load line operates over a very narrow voltage range.

The operating impedance levels of the typical rf solid-state transistor are low, usually 1-10 ohms! This makes the matching networks more complex and lossy. At UHF frequencies the parasitics of the components themselves become a major problem.

The use of higher voltage transistors like the 28-volt types will improve linearity, but require higher supply voltages at lower current. The development of MOS (metal oxide semiconductors) power FETs is a promising field. These devices usually require a 25-60 volt supply, although some lower-power types operate at 12-14 supply voltages.

Proper amplifier operating parameters

Now let's look specifically at power amplifiers. It should be obvious why just about all Amateur amplifiers, especially the commercial types, operate in linear service. Linear amplifiers are less likely to abruptly change power and can be used on any emission type: CW, FM, SSB, or ATV.

Vacuum tubes are still the favorite source of linear power, especially when good IMD and power levels over 100-200 watts are desired. But, the fact that an amplifier uses a vacuum tube is no guarantee that it will be linear. Certain operating parameters must be met. Many of them are described in references 3 and 4. Furthermore, what is often ignored is that for good IMD performance, the type of tube selected is often more important than the operating parameters. If the tube you choose isn't specifically designed for linear service, you probably won't obtain good linear output characteristics — regardless of the operating parameters and circuitry employed.

Generally speaking, at VHF/UHF frequencies, tetrodes have the highest power gain and are usually operated in the grounded-cathode configuration. However, the newer high-mu triodes driven in the ground-grid configuration, while having less gain, will generally deliver the best IMD performance.

Table 1 shows the expected linear performance from some of the most popular tubes Amateurs use. Data has been gleaned from manufacturers data sheets and literature.[5,6]

mation on older tubes (prior to 1970) is almost nonexistent. From the table, it is obvious that the newer high-Mu triodes generally have better IMD performance. Additional parameter information is available in reference 3.

One further caution. The IMD shown in table 1 is an optimized target figure and will vary somewhat with different tubes. These numbers were probably derived under tight laboratory conditions with good instrumentation.

Table 1 is by no means complete. Always get the exact parameters directly from the manufacturers data sheets, not "Joe Ham" down the street. Deviating from the specific operating voltages shown on these data sheets will probably degrade the IMD.

If a tube is driven to higher power levels than shown, the IMD will drop accordingly. As a rough rule of thumb, every time the power output is doubled, the IMD will degrade by at least 6 dB. Going above the output power shown on table 1 is strongly discouraged, unless you want to severely shorten the life of your tubes. Furthermore, you'll gain the ire of every VHF/UHFer in your area who'll be telling you how badly you're splattering.

Solid-state power amplifiers are popular, especially those delivering 10-160 watts. They are generally small in size and only require a single power supply voltage. Reference 7 describes them in detail, along with recommended circuitry. As stated above, the 12-14 volt transistor types are the most common. Some precautions are advised. The power supply should be fairly well regulated and, preferably, adjustable.

Most solid-state amplifiers are specified to operate at approximately 13.5 volts. Dropping the power supply voltage to 12 volts will usually drop the output power by 10-20 percent! Likewise, the IMD will severely degrade.

Pay special attention when wiring the power supply to a solid-state power amplifier. Large diameter wire, no. 14 or larger AWG, is recommended since these amplifiers draw from 5-20A. Small diameter wire will cause a large voltage drop on the power supply lines, with a commensurate decrease in output power and IMD as described above.

As mentioned earlier, solid-state power amplifiers have developed a bad reputation with regards to splatter. There are many reasons for this. As I noted above, the power supply and supply voltage are sometimes to blame. But, the biggest offender is probably the user and his or her interpretation of the manufacturers' specification.

For example, a typical amplifier specification may say "100 watts output with 10 watts of drive." This implies that the amplifier has a true gain of 10 dB.

In reality, the 100 watts of output power may be the maximum output power possible from the amplifier, not the maximum linear output power. Also, the gain may be much higher at the lower output power. Lastly, you may be overdriving the amplifier.

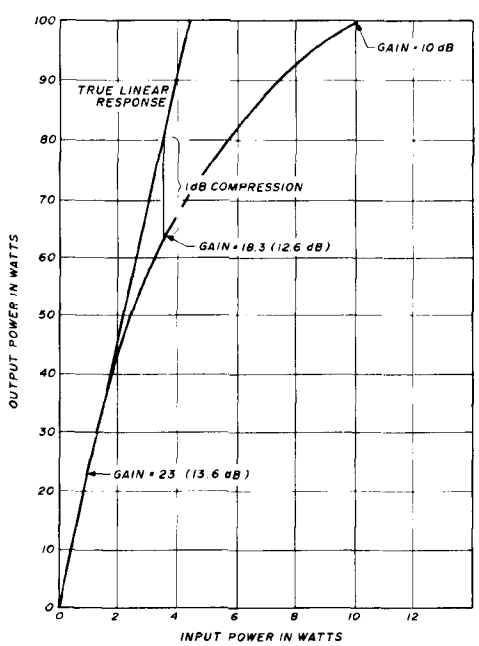
Testing and evaluating power amplifiers

Up to now I've been describing operating parameters. Now let's dig in and see how to test, evaluate, and operate a linear power amplifier. Then you'll be able to better apply this information to your own station.

To better illustrate the point of linearity and specifications, I've plotted on fig. 2 the true output versus input power on a typical Amateur commercial 100-watt VHF solid-state power amplifier. Figure 2 shows that an input power of 1.0 watt yields an output power of approximately 23 watts — a gain of 23 or 13.6 dB. At 3.5 watts input, the output power is approximately 64 watts, a gain of 18.3 or 12.6 dB. Finally, at 10 watts input, the output power is approximately 100 watts; the gain is 10 dB.

Note that the gain isn't constant. What went wrong? The answer is nothing. This output versus input characteristic is typical of the solid-state power amplifiers used by Amateurs. They are linear, but only up to a point.

FIGURE 2



The graph shows the input versus output power from a typical VHF Amateur commercial amplifier. See text for further information on how to interpret the results and perform your own tests.

In a true linear amplifier, a 1-dB input power increase would yield a 1-dB output power increase. In the case of solid-state power amplifiers, linear operation is generally acceptable up to the "1-dB compression point" — the output power level where the gain of the amplifier drops 1.0-dB below the low-power gain.

Said another way, the 1-dB compresssion point is the output power level where the amplifier output increases only 9 db for a 10 dB input power increase. Above this power level distortion and IMD increase rapidly.

Fine you say, but how do I test compression? The easiest way is to use two power meters, one at the input and one at the output of your amplifier (see **fig. 3**). Measure the output power at 5-10 different power levels. The greater the number of data points taken, the greater the accuracy. Plot the results as shown in **fig. 2.**

Next, draw the "true linear response line" from the origin as shown on **fig. 2.** The 1-dB compression point is the measured output power level which is 80-percent (−1 db) below the expected output power (64 versus 80 watts in **fig. 2**).

Power meters

There are several other things to remember when operating a linear. You must have a power meter; an external one is preferable. Without a calibrated power meter you'll never be able to determine if your equipment is operating properly.

There are several caveats when using a power meter. First, *they all* have a time constant. It takes time for the peak power to register, if in fact it ever does. This means that on SSB, the peak power you are running should never show on the meter. If it is, you're driving the rig too hard!

When using a typical power meter, you should be averaging about 25-30 percent *of full linear power* (1-dB compression point) capability. Never exceed 50 percent (see reference 7). Test your linearity, then advance the microphone gain on your exciter and observe the output power. If you ever reach a point where output power no longer increases with increasing microphone gain, back it down!

Say you have an amplifier that puts out 100 watts of linear power, after measuring it according to the methods described above. Set your gain control on the rig so that on average voice it is indicating 25-30 watts, as shown in **fig. 4.** This goes a long way towards insuring that you are not splattering excessively and will still be transmitting full power on peaks!

If your power amplifier has too much gain (the most typical case) you'll have to be careful to keep the microphone gain turned down, or place an attenuator between the exciter and amplifier, or both. You can use a piece of RG-58 cable as an inexpensive moderate-power attenuator.[8] At about 4-5 dB per 100 feet at 2-meters, you may only require 25-75 feet.

If you have ALC capability, use it! It's a great way to control the tendency to overdrive a rig, especially if the amplifier has too much gain.

Other tips

Never use an amplifier unless it's necessary. Remember the FCC regulation that Amateurs should use the minimum power required to maintain communications.

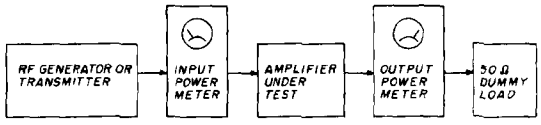
If you overdrive your rig, your signal may still sound great to the station listening to you! Try an A/B test. Switch your amplifier in and out, and have a local station observe the change in signal strength to verify that your gain increases by the number of dB expected from the power amplifier. Then have them tune off 5-10 kHz and repeat the A/B test to see if the IMD degrades with the power amplifier in line.

Remember that all IMD power is wasted and serves no purpose other than to cause interference to adjacent channels![5] Excessive power and overdrive, especially on solid state amps, can also cause premature death to the output devices.

Despite stories to the contrary, the gain of vacuum tube VHF/UHF amplifiers is finite, typically 10-17 dB. Don't expect a 10-watt exciter to drive a 1000-watt amplifier to full output power. You may still need a driver amplifier ahead of the final.

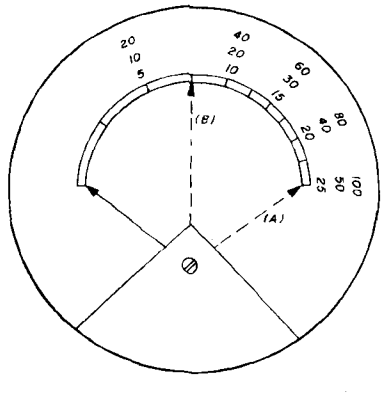
Test all new gear with a local. Problems such as misalignment and breakage can occur during shipment. Carrier supression is sometimes a problem, but can usually be re-

FIGURE 3



This diagram shows a recommended test set up to measure the linearity of a power amplifier as described in the text.

FIGURE 4



This diagram shows the face plate of a typical RF power meter. A is the key-down needle position for maximum linear power. B is the recommended needle position when operating SSB for same as described in text.

tweaked. In rare cases, power amplifiers may have to be re-peaked.

RF actuated power amplifiers can often cause a problem at lower power levels because they may not turn on properly. If possible, try to hard wire the switching on these amplifiers to the station or exciter T/R line.

RF compression is another topic that is really beyond the scope of this month's column. Suffice it to say that if you have it, try it, but only when necessary on weak signal paths. Adjust it carefully and don't use anymore compression than necessary! Remember that rf compression significantly increases dissipation in the power amplifier, which could destroy or shorten device life.

Finally, for many years VHf/UHFers have been gathering at conferences to shoot the bull, measure noise figures, and antenna gains. Maybe it's time we add a new wrinkle to these conferences by setting up workshops to test amplifier power and linearity.

Receiver considerations

So far I've concentrated mostly on the transmitter IMD. I feel that it's most often the culprit and is the easiest problem to deal with. This, of course, isn't always true.

Many of the transceivers used on VHF/UHF, and to a lesser degree those used on hf, have very poor dynamic range. This is especially true of those that were designed before 1985. Furthermore, transceivers and transverters often have poor sensitivity. The latter is not a problem on hf where noise levels are high. But, the typical 6-8 dB noise figures on 2-meters and above often require an external low-noise preamplifier. When such a preamplifier is added, the dynamic range of the receiver drops dramatically.

Low noise preamps don't usually suffer from IMD. However, they usually overdrive the rx following it. The rx has insufficient dynamic range and crashes. If you use an external preamplifier, configure it so that it can be easily bypassed especially if you suspect IMD.

Receiver IMD can usually be tested simply. If you place an attenuator ahead of a receiver, the signal should decrease by the same amount of dBs as the attenuator. However, if the receiver IMD drops by a greater amount, some or all of the IMD is generated by the receiver.

As a rule of thumb, IMD that is generated in a receiver decreases 3 dB for every 1-dB decrease in signal level. A 3-10 dB 50-ohm attenuator pad is a nifty test device. If you suspect a station is causing IMD, note the signal strength and IMD level on the signal strength meter.

Next insert a 3-10 dB attenuator ahead of your receiver/preamplifier. The signal level should drop by the amount of attenuation introduced. If the IMD also drops the same amount, the transmitted signal is probably at fault. If the IMD level drops more than the amount of the attenuator, your receiver is partially at fault. If the receiver IMD drops 3 times the attenuator value, the IMD is probably all generated within your receiver.

You can try one final, simple test. By carefully watching a station on the signal strength meter, you can often see overdrive by observing how much the meter wiggles. A station that's clean will generally cause a typical S meter to move rapidly. A station hitting their transmitter too hard will cause the S meter to sort of hang near the same level because they are in compression.

Summary

This month's column was primarily devoted to improving linearity and decreasing IMD/splatter. Try never to run more power than required. Remember that a true linear doesn't exist. Sooner or later it will run out of gas as the power output is increased. Test your transmitted and received linearity as detailed above and, if you like, try some of the other suggestions I've made.

Note:

In reference 9, I described circuitry to obtain 28 volts from a 12-volt power supply, primarily for operating relays on portable operation. I've been informed that there is a commercial device already available — a Radio Shack Voltage Inverter, catalog number 22-129B. Although it's shown as a 6-12 volt inverter, the instruction sheets clearly show how to use it for a negative ground 12-28 volt inverter. Many thanks to Bill Murray, K2GQI, for bringing this to my attention.

Important VHF/UHF events

October 1-2	*International Region 1 UHF Contest (70-cm and up)*
October 1-2	*Mid-Atlantic States VHF Conference, Warminster, Pennsylvania (contact WB2NPE/WC2K)*
October 9	*Predicted peak of the Draconids meteor shower at 0900 UTC*
October 10	*New moon*
October 20	*Predicted peak of the Orinonids meteor shower at 1400 UTC*
October 23	*EME perigee*
October 22-23	*ARRL International EME contest, first weekend*
November 3	*Predicted peak of the Cassiopids meteor shower at 0245 UTC*
November 3	*Predicted peak of the Taurids meteor shower at 0300 UTC*
November 9	*New moon*
November 16	*Predicted peak of the Leonids meteor shower at 2000 UTC*
November 20	*EME perigee*
November 26-27	*ARRL International EME contest, second weekend.*

References

1. John Grebenkemper, KI6WX, "Phase Noise and its Effects on Amateur Communications," *QST*, March 1988, page 14.
2. E.W. Pappenfus, et al., "Single Sideband Principles and Circuits," McGraw Hill Book Company, 1964.
3. Joe Reisert, W1JR, "VHF/UHF World-VHF/UHF High Power Amplifiers: Part 1," *ham radio*, January 1985, page 97.
4. Joe Reisert, W1JR, "VHF/UHF World-VHF/UHF High Power Amplifiers: Part 2," *ham radio*, February 1985, page 38.
5. Bob Sutherland, W6PO, "Care and Feeding of Power Grid Tubes," Varian Eimac, 1982.
6. *Eimac Power Grid Tubes Quick Reference Catalog 284*, Varian Eimac.
7. Joe Reisert, W1JR, "VHF/UHF World-Medium Power Amplifiers," *ham radio*, August 1985, page 39.
8. Joe Reisert, W1JR, "VHF/UHF World-Transmission Lines," *ham radio*, October 1985, page 83.
9. Joe Reisert, W1JR, "VHF/UHF World-Microwave Portable Operation," *ham radio*, October 1987, page 75.

Article H HAM RADIO



THE HAM NOTEBOOK

Using macros with packet

Computers are supposed to reduce the drudgery of repetitive tasks. When operating packet, I get tired of using the keyboard to enter the same commands over and over. Such tasks can be automated and then invoked when needed by means of a computer programming technique called a "macro". Acording to the Lotus Development Corporation *Lotus 1-2-3 Reference Manual*:

"A macro performs a task automatically. To create a macro, you create a set of entries that describes a particular task keystroke by keystroke, and then name...[it]. To use a macro, you invoke it by pressing...the name of the macro."

If you'd like to tell your computer to send any of the following sample packet commands by using only two or three keys:

CONNECT W1JLI
CONNECT W1JLI-1
CONNECT W1KRU
CONNECT WB1GMA
BE 90
BT HELLO PACKET.. TOM, AD1B
CONVERS

A macro can handle any of these tasks easily. Even better, macros can be designed for your particular needs and utilized in many terminal programs.

I'm using an IBM PC for my packet operations and have chosen the ProComm communications program for terminal emulation. ProComm lets you define up to ten different macros that can be invoked by holding down the ALT key and then pressing any number between 0 and 9. The command line that you have stored is typed on the screen; when you hit the RETURN key, the command is executed. Alternatively, you can include an "embedded" character in the macro so that a carriage return is sent when the macro is invoked.

Consider acquiring ProComm if you're using an IBM or compatible computer for packet or telecommunications. This "shareware" product is distributed by many clubs, bulletin boards, and software vendors at nominal cost. The only charge is a duplication fee which shouldn't exceed $6. If you like the program and use it, you are asked to register your copy with the developers and pay the licensing fee ($25) to: Datastorm Technologies, Inc., P.O. Box 1471, Columbia, Missouri 65205.

There are any number of commercial, shareware, and public domain programs that can be used to store combinations of keystrokes for later use. ProComm comes with an option to store up to ten different macros in the program itself. To access this option, you need only call the macro menu.

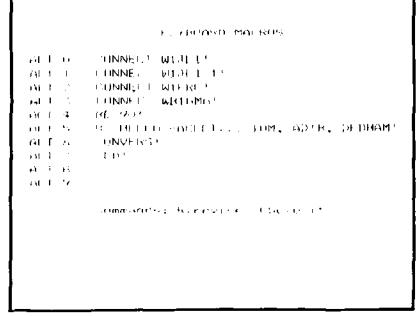
You can create and edit macros by holding down the ALT key and striking the "M" key (ALT-M). When you do this, a small menu appears that allows the definition of the ten available macro strings used as command lines.

Each macro is a string of up to 36 characters in length; it may contain embedded control codes (such as the CONTROL character) and carriage returns. You don't need to hit the RETURN key if you choose to use an embedded carriage return; it is sent automatically when you use the macro.

Figure 1 gives an example of the macro screen that is used to define or change a macro. It also contains samples of typical macros. The steps are simple:

- Call the macro menu with the ALT-M option.
- Type "R" to revise a macro.
- Strike a number (from 0 to 9) to select or name a macro.
- Enter the text string that you want to use.
- Respond with the letter "Y" to save the new macro.
- Revise another macro or hit the "ESCAPE" key to exit.

FIGURE 1



Macro screen.

Notice that all my macros end with an exclamation point. ProComm has a feature called Output String Translation — the program treats predefined characters in a special manner. The exclamation point is interpreted as a

carriage return; a caret ("^") is interpreted as the "control" character. If you want to send Control-C, include the "^C" string in your macro. Notice that macro number 7 in **fig. 1** is the command "^CD!". This provides a Control-C (to call the command line on my terminal unit) and a D (for disconnect) followed by a carriage return. Macro number 7 is designed to disconnect and return to the command line.

Once the program is set up, you can use macros to speed up the entry of your ten most common terminal commands and execute them with only two keystrokes. If you forget the definition of any particular macro key, simply use the ALT-M combination to see the macro menu. I like macros; they provide an effortless way to get around that keyboard.

Thomas M. Hart, AD1B

SEND FOR FREE 1988 CATALOG... 56 PAGES

★ QUALITY PARTS ★ DISCOUNT PRICES ★ FAST SHIPPING

ALL ELECTRONICS CORP.

WE STOCK OVER 4,000 ITEMS... CALL OR WRITE FOR OUR *FREE CATALOG OF PARTS!*

RESISTORS • CAPACITORS • DIODES • CABLES • BRIDGE RECTIFIERS • CHOKE COILS • CRYSTALS • CRIMP CONNECTORS • LAMPS • HEAT SINKS • MOTORS • SUB MINIATURE D CONNECTORS • TRANSISTORS • IC'S • PROTO BOARDS • POTENTIOMETERS • POWER SUPPLIES • JACKS • PLUGS • SWITCHES • PERF BOARDS • FANS • FUSES • SHRINK TUBING • TIE WRAPS • TOOLS • KEYPADS • VIDEO ACCESSORIES • RELAYS • SCR'S • TRANSFORMERS • TELEPHONE ACCESSORIES • RIBBON CABLE • CIRCUIT BREAKERS • VOLTAGE REGULATORS • AND MANY OTHER ITEMS

TRANSISTORS

CAT#	TYPE	CASE	PRICE
2N2222	NPN	TO-92	5 for 75¢
2N2904	PNP	TO-5	3 for $1.00
2N2906	PNP	TO-18	3 for $1.00
2N2907	PNP	TO-92	5 for 75¢
2N3055	NPN	TO-3	$1.00 each
2N3439	NPN	TO-66	5 for 50¢
2N3904	NPN	TO-92	5 for 75¢
2N3906	PNP	TO-92	5 for 75¢
2N4400	NPN	TO-92	5 for 75¢
2N4403	PNP	TO-92	5 for 75¢
2N5400	PNP	TO-92	4 for $1.00
2N5550	NPN	TO-92	4 for $1.00
2N5551	NPN	TO-92	4 for $1.00
2N6027	PUT	TO-92	2 for $1.00
2N6292	NPN	TO-220	75¢ each
MJE2955T	PNP	TO-220	75¢ each
MJE3055T	NPN	TO-220	75¢ each
TIP30	NPN	TO-220	75¢ each
TIP31	NPN	TO-220	75¢ each
TIP32	PNP	TO-220	75¢ each
TIP41	NPN	TO-220	75¢ each
TIP42	PNP	TO-220	75¢ each
TIP121	NPN	TO-220	75¢ each
TIP126	PNP	TO-220	75¢ each

10 AMP SOLID STATE RELAYS

ELECTROLF S218I CONTROL
Rated 5.5 to 10 Vdc will operate on 3-32 Vdc
LOAD
10 Amp @ 240 Vac
2 1/4" X 1 3/4" X 7/8"
CAT# SSRLY-10B
$9.50 each
QUANTITY DISCOUNT!
10 for $85.00
25 for $175.00
50 for $300.00
100 for $500.00

SWITCHES

MINIATURE TOGGLE SWITCHES
all rated 5 Amps

S.P.D.T.(on-on)
Solder lug terminals
CAT# MTS-4
$1.00 each
10 for $9.00

S.P.D.T.(on-on)
Non threaded bushing
P.C. mount
CAT# MTS-40PC
75¢ each
10 for $7.00

D.P.D.T.(on-on)
Solder lug terminals
CAT# MTS-6
$2.00 each
10 for $19.00

MINI PUSH BUTTON
S.P.S.T. momentary.
Push to make. 1/4" threaded bushing
Red button
CAT# MPB-1
35¢ each • 10 for $3.25

ITT PUSH BUTTON
ITT MDPL series. 3/4" X 1/2" gray rectangular key cap
S.P.S.T. N.O. Push to close
RATED
0.1 amp switching,
0.25 amp carry current. P.C. mount
CAT# PB-8 65¢ each
10 for $6.00 • 100 for $50.00

HALL EFFECT SWITCH
MICROSWITCH 91SE3
Standard keyboard switch with hall effect sensor
Snaps into 5/8" square chassis hole. Hall effect sensor slides easily from switch and can be used in other applications
CAT# HESW 4 for $1.00
10 for $2.00
100 for $15.00

PIEZO WARNING DEVICE

Murata Erie # PKB6-4A0
High pitched audible alarm
Operates on 3 - 20 Vdc @ 20 ma. 1" High X 7/8" dia. P.C. Board mount
CAT# PBZ-84 $1.75 each

SOUND ACTIVATED BOARD

Designed to react to high pitched sources. Each board contains many useful parts including a condenser mic. Operates on 6 Vdc. Instructions included
CAT# SAB $2.50 each

24 VOLT D.C. SOLENOID

Intermittent duty cycle. 240 ohm coil
Mounting flange is 1 1/8" wide
Solenoid body 1 1/2" X 1/2" X 1/2"
CAT# SOL-24 $1.00 each • 10 for $8.50
100 for $75.00 *Large Quantity Available*

XENON TUBE

1" long flashtube prepped with 3 1/2" red ⁄ black leads. Ideal for electronic flash or strobe projects
CAT# FLT-3 2 for $1.00

***NEW!* STROBE KIT**

Variable rate strobe kit. Flashes between 60 to 120 times per minute. Will operate on either 6 or 12 Vdc depending upon how you wire the circuit. Comes complete with P.C. board and instructions for easy assembly.
CAT# STROBE-1 $7.50 each

SOUND & VIDEO MODULATOR

#14 UM1381-1
Designed for use with T.V. computers. Can be used with video cameras, games, or other audio/video sources. Built in A/B switch enables user to switch from T.V. antenna without disconnection. Operates on channel 3 or 4. Requires 12 Vdc. Hook up diagram included
CAT# AVMOD $5.00 each

GRAB BAGS $1.00 EACH

50 ASSORTED DISC CAPS. Cut leads. Many common values, some are 500 volts
CAT# GHADDC

ASSORTED 1/4 WATT RESISTORS
Approximately 200 pieces of assorted values, some cut leads
CAT# GRES

ASSORTED PARTS
Strips of 100 assorted parts. Each strip contains an assortment of resistors, capacitors, diodes, coils, etc. 100 pieces
CAT# GRABTR

15 VALUES OF ELECTROLYTICS
Assortment contains 15 values of 1 mfd and up. Some cut leads.
CAT# GRABCH

NICKEL-CAD (RECHARGEABLE) BATTERIES

SPECIAL
AAA SIZE
Panasonic # P-15AAA
1.2 volt @ 180 mAH
CAT# NCB-AAAX
$1.50 each
10 for $13.50
100 for $125.00
LARGE QUANTITIES

AA SIZE $2.00 each
1.25 Volts 500 mAh
CAT# NCB-AA

AA SIZE $2.20 each
WITH SOLDER TABS
CAT# NCB-SAA

C SIZE $4.25 each
1.2 Volts 1200 mAh
CAT# NCB-C

D SIZE $4.50 each
1.2 Volts 1200 mAh
CAT# NCB-D

WALL TRANSFORMERS

ALL PLUG DIRECTLY INTO 120 VAC OUTLET

9 Vdc @ 200 mA. $2.25
CAT# DCTX-920

6 Vdc @ 750 mA. $3.50
CAT# DCTX-675

8 Vdc @ 250 mA. $2.50
CAT# DCTX-025

12 Vac @ 830 mA. $3.50
CAT# ACTX-1293

18 Vac @ 1 Amp. $3.50
CAT#ACTX-1885

PROTO BOARD

Large enough to design most experimental circuits. This proto board measures 6 3/4" X 2 1/2". Contains main board and two power buss strips
CAT# PB-101
$9.00 each

FULL WAVE BRIDGE RECTIFIERS

10 AMP
200 P.I.V.
3/8" SQUARE
CAT# FWB-1020
$1.00 each • 10 for $9.00

25 AMP RATING
1 1/8" SQUARE
metal epoxy filled case
200 P.I.V. $2.50 each
CAT# FWB-252
400 P.I.V. $3.00 each
CAT# FWB-254
600 P.I.V. $3.50 each
CAT# FWB-258
LARGE QUANTITY AVAILABLE...

N-CHANNEL MOSFET

IRF-511
TO-220 case
CAT# IRF 511
$1.00 each
10 for $9.00
LARGE QUANTITY AVAILABLE...

FLASHING L.E.D. KIT

Two L.E.D.'S flash in unison when a 9 volt battery is attached
Requires easy assembly, you solder the parts to the circuit board
CAT# LEDKIT
$1.50 each

WATER TIGHT ENCLOSURE

ROSE# 02081905
Molded fiberglass enclosure with neoprene gasket
2" X 3" X 7 1/2". Light blue
CAT# WP-905 $7.50 each

LIGHT EMITTING DIODES (L.E.D.)

STANDARD JUMBO LED
DIFFUSED T 1-3/4 size
RED 10 for $1.50
CAT# LED-1 100 for $13.00
1000 for $110.00
GREEN 10 for $2.00
CAT# LED-2 100 for $17.00
1000 for $150.00
YELLOW 10 for $2.00
CAT# LED-3 100 for $17.00
1000 for $150.00

FLASHING LED
with built in flashing circuit
operates on 5 volts
RED $1.00 each
CAT# LED-4 10 for $9.50
GREEN $1.00 each
CAT# LED-4G 10 for $9.50

BI-POLAR LED
Lights RED one direction, GREEN the other. Two leads
CAT# LED-5 2 for $1.70

LED HOLDER
Two piece holder
CAT# HLED
10 for 65¢

CLIPLITE LED HOLDER
Makes a L.E.D. look like a fancy indicator
Fits T 1-3/4 size LED
CLEAR CAT# HLDCL-C
RED CAT# HLDCL-R
GREEN CAT# HLDCL-G
YELLOW CAT# HLDCL-Y

MAIL ORDERS TO:
ALL ELECTRONICS
P.O. BOX 567
VAN NUYS, CA 91408

TWX-5101010163
(ALL ELECTRONIC)

OUTSIDE THE U.S.A. SEND $1.50 POSTAGE FOR A CATALOG!!

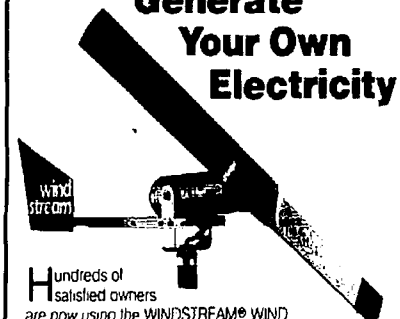
TOLL FREE
800-826-5432
INFO: (818)904-0524
FAX: (818)781-2653
MINIMUM ORDER $10.00
QUANTITIES LIMITED

CALIF. ADD SALES TAX
USA: $3.00 SHIPPING
FOREIGN ORDERS INCLUDE SUFFICIENT SHIPPING.
NO C.O.D.

STORES: LOS ANGELES 905 S. VERMONT AVE. LOS ANGELES, CA 90006 (213)380-8000
VAN NUYS 6238 SEPULVEDA BLVD. VAN NUYS, CA. 91411 (818)997-1806

✓ 154

Generate Your Own Electricity



Hundreds of satisfied owners are now using the WINDSTREAM® WIND GENERATOR to provide power for RVs, weekend cottages, boats, workshops, remote locations, emergency back up power and much more
Portable—weighs only 20 lbs—easily installed with our comprenensive installation manual—minimum maintenance—full warranty

✓ 155

Tharmax Corporation H
P.O. Box 3128, Burlington, VT 05401-3128

VISA

ICOM

MasterCard

VHF COMMUNICATIONS

INTRODUCING W2DRZ VHF/UHF MODULES. NOW AVAILABLE.

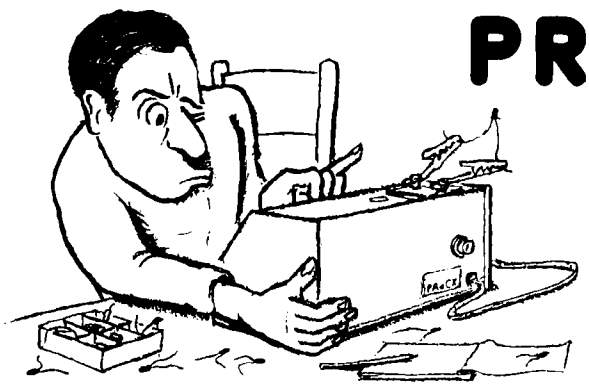
ICOM, AEA, LARSEN, VAN GORDEN, VIBROPLEX, NYE-VIKING, FALCON COMM, LEADING EDGE, ARRL PUBLICATIONS, KAGLO, HAMTRONICS, PROWRITER, ELEPHANT DISKS, DEBCO, TRIONYX

✓ 156

915 North Main Street
Jamestown, New York 14701

Western New York's finest... amateur radio dealer!

PH. (716)664-6345



PRACTICALLY SPEAKING

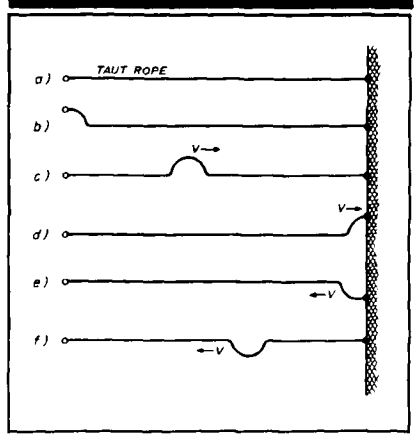
Joe Carr, K4IPV

Standing waves: a review

Standing waves are always a consideration when dealing with antennas, transmission lines, and other rf source/load combinations. This month I'll take a brief look at standing waves, how they're calculated, how they're measured, and what they mean.

The reflection phenomenon was mentioned in last month's discussion of the step function or single-pulse response of a transmission line; the same phenomenon applies when the transmission line is excited with an ac signal. Let's review what happens in a transmission line system under ac excitation by using a little metaphorical device — the old rope trick. In **fig. 1** a taut rope is anchored at one end to an inflexible wall (**1A**). If a pulse is initiated by wiggling the free end of the rope (**1B**), the displacement wave will propagate down the rope (**1C**) until it hits the wall (**1D**). At this point the wave is reflected (**1E**) and repropagates back down the rope toward the source (**1F**). In this case, there is a 180-degree phase reversal, but that only happens in some transmission line situations (in other cases the reflected wave is in phase with the incident wave).

FIGURE 1



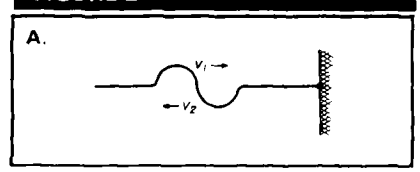
"Taut rope" metaphor for standing waves.

If the free end of the rope (our metaphorical "transmitter") is moved up and down, the rope oscillates and produces a series of waves. When an incident wave crosses a reflected wave the two will add algebraically as shown in **fig. 2A**. The amplitude at any given point is the sum of the two wave amplitudes; it may be either greater or less than the individual waves.

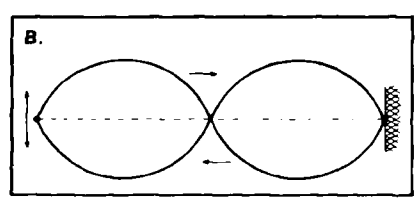
Figure 2B shows a situation in which the oscillations are recurrent in such a way that they produce standing waves on the rope. In this case, an observer looking from the side would see what appears to be a single wave pattern standing in free space.

If a transmission line is perfectly matched to the load, no power is reflected back towards the source. This situation is analogous to a rope connected to a perfectly distensible foam rubber wall that absorbs all the mechanical energy of the rope wave. When a transmission line isn't matched to its load, some of the energy is absorbed by the load and some is reflected back down the line towards the source. This situation is

FIGURE 2



When incident and reflected waves interfere, the resultant is the algebraic sum of the two.



Oscillations on the input give rise to standing waves.

analogous to a rope connected to a somewhat distensible wall that absorbs some energy and reflects the rest. The interference of incident (forward) and reflected (reverse) waves creates standing waves on the transmission line.

The voltage or current measured along the line vary, depending on the load (see **fig. 3**). The voltage-vs.-length curve for a matched line is shown in **fig. 3A**, where $Z_L = Z_0$. The line is said to be "flat" because the voltage and current remain constant along the line. **Figure 3B** shows the voltage distribution over the length of the line when the load end of the line is shorted ($Z_L = 0$). At the load end the voltage is zero, a result of zero impedance. The same impedance and voltage situation is repeated every half wavelength down the line from the load end towards the generator. Voltage minima are called nodes, while voltage maxima are called antinodes.

The pattern in **fig. 3C** occurs when the line is not terminated (open); that is, Z_L is infinite. The pattern is the same shape as **fig. 3B** (shorted line), but phase shifted 90 degrees. In both cases the reflection is 100 percent, but the phase of the reflected wave is shifted 90 degrees.

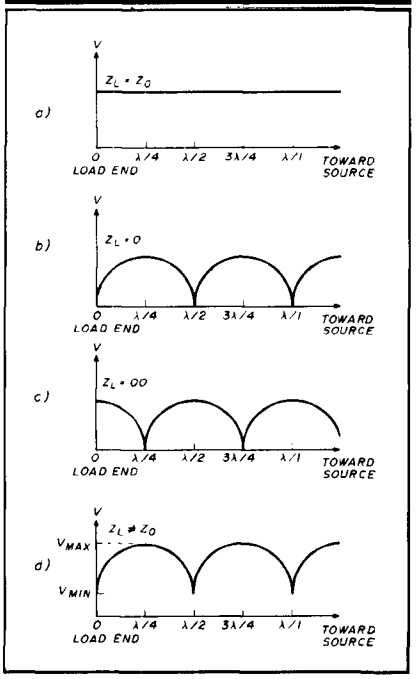
Figure 3D shows the situation where Z_L is not equal to Z_0; it is neither zero nor infinite. In this case the nodes represent some finite voltage, V_{min}, rather than zero. The standing wave ratio (SWR) reveals the relationship between load and line.

If the current along the line is measured, the pattern will resemble the patterns of **fig. 3**. The SWR is then called ISWR, to indicate that it came from a current measurement. It is called VSWR if the SWR is derived from voltage measurements. VSWR is the term most commonly used, perhaps because voltage is easier to measure.

VSWR can be specified in any of several equivalent ways:
From incident voltage (V_i) and reflected voltage (V_r):

$$VSWR = \frac{V_i + V_r}{V_i - V_r} \qquad (1)$$

FIGURE 3



(A) Voltage vs. Length characteristic of transmission line: (a) flat line ($Z_L = Z_0$), (b) shorted line, (c) open line, (d) mismatched line.

From transmission line voltage measurements (**fig. 3D**):

$$VSWR = \frac{V_{max}}{V_{min}} \qquad (2)$$

From load and line characteristic impedance:
($Z_L > Z_0$) VSWR = Z_L/Z_0 (3)
($Z_L < Z_0$) VSWR = Z_0/Z_L (4)
From incident (P_i) and reflected (P_r) power:

$$VSWR = \frac{1 + [P_r/P_i]^{1/2}}{1 - [P_r/P_i]^{1/2}} \qquad (5)$$

From reflection coefficient (p):

$$VSWR = \frac{1 + p}{1 - p} \qquad (6)$$

It's also possible to determine the reflection coefficient (p) from knowledge of VSWR:

$$p = \frac{VSWR - 1}{VSWR + 1} \qquad (7)$$

VSWR is usually expressed as a ratio. For example, when Z_L is 100 ohms and Z_0 is 50 ohms, the VSWR is Z_L/Z_0 = 100 ohms/50 ohms = 2, or VSWR = 2:1. VSWR can also be expressed in decibel form:
VSWR = 20 log (VSWR)

The SWR is important in systems for several reasons. At the root of it all is the fact that the reflected wave represents energy lost to the load. For example, in an antenna system less power is radiated if some of its input power is reflected back down the transmission line. This is because the antenna feedpoint impedance doesn't match the transmission line characteristic impedance. Now let's take a look at the problem of mismatch losses.

Mismatch (VSWR) losses

The power reflected from a mismatched load represents lost energy and, depending on the situation, will have implications that range from negligible to profound. A result might be anything from a slight loss of signal strength at a distant point from an antenna, to destruction of the output final amplifier device in a radio transmitter. The latter problem so plagued early solid-state transmitters that designers opted to include shutdown circuitry to sense high VSWR and limit output power proportionally.

VSWR on the transmission lines interconnecting devices under test, instruments, and signal sources can cause erroneous readings in radio system measurements, making them invalid. This problem is important, especially at VHF and with microwaves where transmission line lengths between signal sources, amplifiers, and indicating instruments are either an appreciable fraction of a wavelength or greater than a wavelength at those frequencies. For my MMIC column a few months back I built an amplifier that worked from near dc to 1 GHz or so. After making measurements above 400 MHz, I came up with a situation where there was more gain than the amplifier could offer. The "free" signal was actually wave combination in phase and *not* the gain of the MMIC amplifier.

You must take two VSWR situations into account when determining VSWR losses. Consider a transmission line of impedance Z_0 interconnecting a load impedance (Z_L) and a source with an output impedance (Z_s). There is a potential for impedance mismatch at both ends of the line.

Where one end of the line is matched (either $Z_s = Z_0$) or ($Z_L = Z_0$), the mismatch loss due to SWR at the mismatched end is:

$$ML = -10 \log \left[1 - \left(\frac{SWR - 1}{SWR + 1} \right)^2 \right] \quad (8)$$

This can also be written as:
$ML = -10 \log (1 - p^2)$

Example

A coaxial transmission line with a characteristic impedance of 50 ohms is connected to the 50-ohm output (Z_0) of a signal generator, and also to a 20-ohm load impedance (Z_L). Calculate the mismatch loss.

Solution:
First find the VSWR:
$VSWR = Z_0/Z_L$
$VSWR = 50 \text{ ohms}/20 \text{ ohms} = \mathbf{2.5:1}$
Mismatch loss:

$$ML = -10 \log \left[1 - \left(\frac{SWR - 1}{SWR + 1} \right)^2 \right] \quad (9)$$

$$ML = -10 \log \left[1 - \left(\frac{2.5 - 1}{2.5 + 1} \right)^2 \right]$$

$$ML = -10 \log \left[1 - \left(\frac{1.5}{3.5} \right)^2 \right]$$

$ML = -10 \log [\, 1 - (0.43)^2]$
$ML = -10 \log [\, 1 - 0.185\,]$
$ML = -10 \log [0.815]$
$ML = (-10)(-0.089) = 0.89$

When both ends of the line are mismatched a different equation is required:
$ML = 20 \log [1 \pm (p_1 \times p_2)]$ (10)
Where:
p_1 is the reflection coefficient at the source end of the line, $(VSWR_1 - 1)/(VSWR_1 + 1)$
p_2 is the reflection coefficient at the load end of the line, $(VSWR_2 - 1)/(VSWR_2) + 1)$

Note that the solution to **eqn. 10** has two values: $[1 + (p_1p_2)]$ and $[1 - (p_1p_2)]$.

The preceding equations reflect the mismatch loss solution for low loss or "lossless" transmission lines. They are close approximations, but there are situations where they are insufficient — namely when the line is lossy. Though not very important at low frequencies, loss becomes significant at VHF through microwave frequencies. Interference between incident and reflected waves produces increased current at certain antinodes (which increases ohmic losses) and increased voltage at certain antinodes (which increases dielectric losses). The latter increases with frequency. **Equation 11** relates reflection coefficient and line losses to determine total loss on a given line.

$$loss = 10 \log \left[\frac{n^2 - p^2}{n - np^2} \right] \quad (11)$$

Where:
loss is the total line loss in decibels
p is the reflection coefficient
n is the quantity $10^{(A/10)}$
A is the total attenuation in dBs presented by the line, when the line is properly matched ($Z_L = Z_0$)

Example

A 50-ohm transmission line is terminated in a 30-ohm resistive impedance. The line is rated at a loss of 3 dB/100 feet at 1 GHz. Calculate the loss in 5 feet of line, the reflection coefficient, and the total loss in a 5-foot line mismatched as above.
solution:

$$A = \frac{3dB}{100\ ft.} \times 5\text{-}ft = 0.15dB \quad (12)$$

$$p = \frac{Z_L - Z_o}{Z_L + Z_o} \quad (13)$$

$$p = \frac{50 - 30}{50 + 30}$$

$p = 20/80 = \mathbf{0.25}$
$n = 10^{(A/10)}$
$n = 10^{(0.15/10)}$
$n = 10^{(0.015)} = \mathbf{1.04}$

$$loss = 10 \log \left[\frac{n^2 - p^2}{n - np^2} \right] \quad (14)$$

$$loss = 10 \log \left[\frac{(1.04)^2 - (0.25)^2}{(1.04) - ((1.04)(0.25)^2)} \right]$$

$$loss = 10 \log \left[\frac{1.082 - 0.063}{(1.04) - ((1.04)(0.063))} \right]$$

$$loss = 10 \log \left[\frac{1.019}{1.04 - 0.066} \right]$$

$$loss = 10 \log \left[\frac{1.019}{0.974} \right]$$

loss = 10 log (1.046)
loss = (10)(0.02) = **0.2dB**

Compare the matched line loss (A = 0.15 dB) with the total loss (loss = 0.2 dB), which includes mismatch loss and line loss. The difference (loss − A) is only 0.05 dB. If the VSWR were considerably larger, the loss would rise. Work through some basic examples using VSWR values seen in Amateur Radio work; the answers may surprise you. Considering that an S unit is either 3 or 6 dB depending on which receiver you own, it isn't necessary to tweek out every litle bit of VSWR. In fact, the only reasons to worry about it are that: the VSWR low point indicates resonance on the antenna, and solid-state final amplifiers are not too happy with VSWR.

Trimming the transmission line does *not* lower VSWR, despite what non-ideal instruments may lead you to believe. To reduce VSWR, you must either resonate the antenna or insert an impedance-matching device between the line and the antenna. The only time that transmission line can reduce VSWR is when it is used as a matching section, as discussed last month.

Editor's Note: This material was derived from Joe's forthcoming book, *Practical Antenna Handbook*. Joe Carr, K4IPV, can be reached at POB 1099, Falls Church, Virginia 22041; he'd like to have your comments and suggestions for this column.

Article J **HAM RADIO**

MORE FIXES FOR THE IC22S VHF RADIO

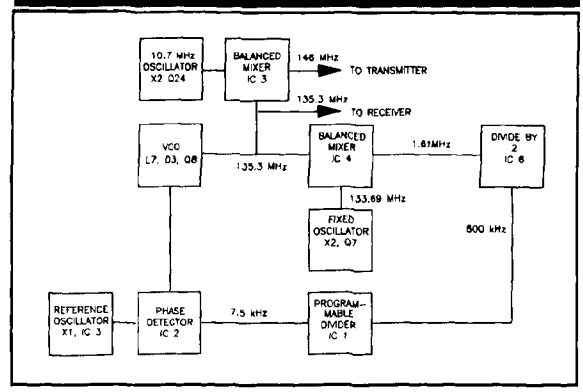
By Brian J. Henderson, VE6ZS, 23 Deermoss Place SE, Calgary, Alberta T2J 6P5 Canada

In its day, the Icom IC22S was one of the most popular radios sold. I still own two and have needed to repair them on a few occasions. One had a number of problems requiring major work. The radio's only shortcoming is that its manual gives little more than a circuit diagram;* I didn't find it particularly helpful. Some of the problems I've encountered and corrected are outlined here.

Theory and operation

A simplified block diagram is shown in **fig. 1**. A voltage-controlled oscillator (VCO) generates the frequencies required for the receiver and transmitter. The VCO operates at 135.3 MHz, the frequency required for receiver injection. The components used for phase detection and division won't operate at these high frequencies. The signal is mixed with a fixed frequency of 133.69 MHz generated by crystal X2 and Q7, which operate as a tripler. The difference between these two is 1.61 MHz. This signal is further divided by 2, by IC 6, and passed on to the programmable voltage divider, IC 1. The division of the signal by IC 1 is set by the diode matrix board and associated logic. The divided frequency is passed on to the phase comparator, IC 2. The frequency at this point should be about 7.5 kHz. Phase is compared with a reference 7.5-kHz signal produced by crystal X1 and fixed divider IC 3. The difference in phase and frequency between the fixed reference and the variable signal from the VCO is converted by IC 1 to a dc voltge (offset error voltage). The dc voltage is used to control the capacitance of D3 in the VCO. Changing the capacitance in the VCO will change its output frequency. The correction process continues until the VCO has the correct output frequency. This is achieved when the phase error between the reference and divided generated frequencies is reduced to zero. The PLL is then said to be "locked." When changing channels, or going from transmit to receive, repeat this process to give the required frequencies for the radio to operate.

FIGURE 1



Block diagram of the PLL in the IC22S.

Frequency alignment

Make adjustments in the following order using a frequency counter, signal generator, and a plastic tuning tool.

- **Reference Oscillator**

Connect the counter to test point CP1 on the PLL board (located on the lower left corner of the PLL board). Adjust C2 for a frequency of 7.68 MHz (European version 10.24 MHz).

- **Receive Frequency**

Using a signal generator, inject a signal on a channel the radio can receive. The wire originally connected to pin 1 of the accessory socket is the discriminator output. Adjust C38 on the PLL board (lower left corner of board next to crystal X2) for zero discriminator current as measured between this point and chassis ground.

- **Transmit Frequency**

Most radios are usually on frequency and require no adjustment; should yours need it, transmit on a known frequency. If the radio is off frequency, as displayed on the counter, adjust L41 (located at the front, near the left corner of the main board) for the correct transmit frequency.

VCO adjustment

I've had several problems with cold weather and PLL lockup. No specifications were given in the manual. Set the radio to 147 MHz (or the center of your desired operating range). Monitor the voltage between pin 1 of IC 2 and ground. Adjust L7 (inside the VCO can) for a voltage of 3.5 volts. This won't affect the frequency of operation if the radio has been adjusted according to the previous steps. Note that the radio's maximum operating bandwidth is approximately 2.5 MHz. Bear this in mind when choosing the center frequency.

PLL board jumpers

I traced a number of intermittent PLL lockup problems to the jumpers connecting the top and bottom of the PLL board. The original board didn't use plated-through holes, and these jumpers connected the top and bottom. Stainless steel wire was used originally; it doesn't solder well. Remove all these jumpers and replace them with tinned copper wiring. There are about 20 jumpers to replace.

PLL logic

The radio will work in simplex mode below 146 MHz if the VCO is adjusted as I explained above. However, the logic won't add the correct offset for the 600-kHz shift normally required if it's in the duplex mode. I added IC 11 (two gates) to correct this design problem. The gates can be installed by cutting traces, but I've had numerous problems with broken circuit traces on the PLL board. I removed all four existing ICs of the logic circuit (ICs 7, 8, 9, and 10) and built an entirely new logic board. I used wire-wrap techniques to construct the board and *mounted* it with L-brackets. The L-brackets attach to the sides of the chassis towards the rear, underneath the normal position of the speaker. Be sure to leave a 1-inch (2.5 cm) space between IC 7 and 8, and IC 9 and 10 for the speaker coil. I found that the wire-wrap pins were too long and interfered with the solder side of the main board when mounting this extra board. I cut off the excess pins so there was sufficient clearance for mounting.

Wire the extra board to the diode matrix board plug-in connection block on the PLL board. Resistors R36 and R37 are shown in **fig. 2**. These resistors are already installed in the radio. You don't have to add them if the input wiring to the logic board (D0-D7) is wired directly to the diode matrix board plug.

Wiring out of the logic board (D0-D2, P3-P7) connects to the input pins of the programmable divider (IC 1). These connections are shown on the original schematic. D0, D1, and D2 don't go through the logic board. They connect directly to pins 1, 2, and 3 of the programmable divider.

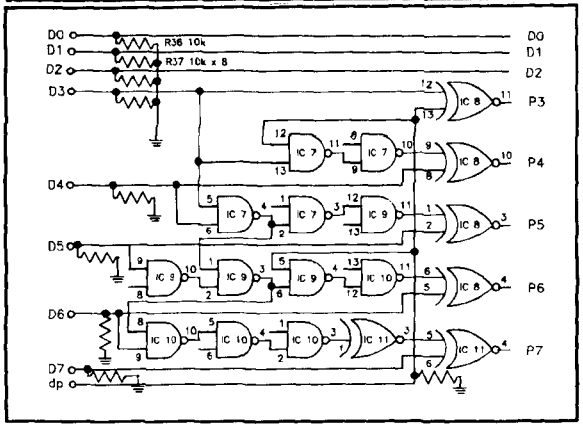
Common 4000 or 14000 series chips can be used as direct replacements for ICs 7, 8, 9, and 10 if removed or damaged. After installing this extra circuit board, I've had virtually no further intermittent problems with the PLL board.

Microphonics

One of the largest problems with frequency synthesizers is the mechanical vibration of the components in the synthesizer. This vibration can be heard as audio on an FM transmitter. It can also be heard in the speaker as an "echo" or hollow sound during receive. These vibrations are called "microphonics" and can result from speaker or microphone audio being coupled to the synthesizer. This means that everything inside the VCO must be "glued" together so it won't move mechanically.

There is a resin or hard material inside the VCO shielded box holding everything together so that it won't vibrate. If you remove it, you must replace it for the radio to operate without these microphonics. Beeswax is the easiest material to use. It's chemically inert and melts at

FIGURE 2



Schematic of the duplex offset logic board showing the addition of IC11.

temperatures low enough that it will not damage components. You can find beeswax in sewing and fabric stores.

The beeswax can be melted in a small container, poured in, and allowed to set. Don't fill the VCO can completely — just enough to cover the components and keep them from vibrating. If it becomes necessary to remove the beeswax for further servicing, remove the VCO can and heat with a candle. The beeswax will melt and run out.

Component substitution

The original components can usually be replaced with substitutes from any cross-reference book. One com-



Make the most of your general coverage transceiver with *Monitoring Times*!

Every month Monitoring Times brings everything you need to make the most of your general coverage transceiver: the latest information on international broadcasting schedules, frequency listings, international DX reports, propagation charts, and tips on how to hear the rare stations. Monitoring Times also keeps you up to date on government, military, police and fire networks, as well as tips on monitoring everything from air-to-ground and ship-to-shore signals to radioteletype, facsimile and space communications.

ORDER YOUR SUBSCRIPTION TODAY before another issue goes by. In the U.S., 1 year, $18; foreign and Canada, 1 year, $26. For a sample issue, send $2 (foreign, send 5 IRCs). For MC/VISA orders ($15 minimum), call 1-704-837-9200.

MONITORING TIMES

Your authoritative source, every month.

P.O. Box 98 A
Brasstown, N.C. 28902

167

W6SAI BOOKS

published by Bill Orr, W6SAI and Stu Cowan, W2LX

BEAM ANTENNA HANDBOOK
Completely revised and updated with the latest computer generated information on BEAM Antenna design. Covers HF and VHF Yagis and 10, 18 and 24 MHz WARC bands. Everything you need to know. 204 illustrations. 268 pages. ©1985. Revised 1st edition.
☐ IRP-BA — Softbound $11.95

SIMPLE LOW-COST WIRE ANTENNAS
Primer on how-to-build simple low cost wire antennas. Includes invisible designs for apartment dwellers. Full of diagrams and schematics. 192 pages. ©1972 2nd edition
☐ IRP-WA — Softbound $11.95

ALL ABOUT CUBICAL QUAD ANTENNAS
Simple to build, lightweight, and high performance make the Quad at DX'ers delight. Everything from the single element to a multi-element monster. A wealth of information on construction, feeding, tuning and installing the quad antenna. 112 pages. ©1982. 3rd edition.
☐ IRP-CQ — Softbound $9.95

THE RADIO AMATEUR ANTENNA HANDBOOK
A wealth of projects that covers verticals, long wires, beams as well as plenty of other interesting designs. It includes an honest judgement of gain figures, how to site your antenna for the best performance, a look at the Yagi-Quad controversy, baluns, slopers, and delta loops. Practical antenna projects that work! 190 pages. ©1978. 1st edition.
☐ IRP-AR — Softbound $11.95

Please enclose $3.50 for shipping and handling. VISA

HAM RADIO BOOKSTORE
GREENVILLE, NH 03048 (603) 878-1441

ponent I found particularly difficult to replace was the varactor diode in the PLL circuit. Cross-referencing the original part was next to impossible. By trial and error and some calculations, I determined that the diode I needed was a 1N5441A, MV 2101, or ECG610 varactor diode.

Circuit board cleaning

It appeared that the flux from component soldering was never removed when the board was manufactured. Flux is quite corrosive and will eventually eat its way through a circuit board. Remove as much of it as you can with flux remover, available at most electronics stores.

Nine-volt supplies

There are three 9-volt regulated power supplies in the radio: one common, one for transmit, and one for receive. Each 9-volt regulator transistor has a 15-ohm resistor in series with the collector. This resistor was originally installed with a power rating of 1/4 watt. I recommended that you change R141, R144, and R149 to a 1-watt rating, as the original components run too hot.

Transmitter tuning

Six trimmer capacitors are involved in aligning the transmitter. Set the radio to a frequency below the midpoint of the desired operating range — for example, 146.5 MHz if the center of the operating range is 147 MHz. Adjust C97, C100, C92, C91, C85, and C81 in that order for maximum power output into a matched load. Repeat these adjustments at least once.

Other adjustments

Here are some other common adjustments inside the radio:

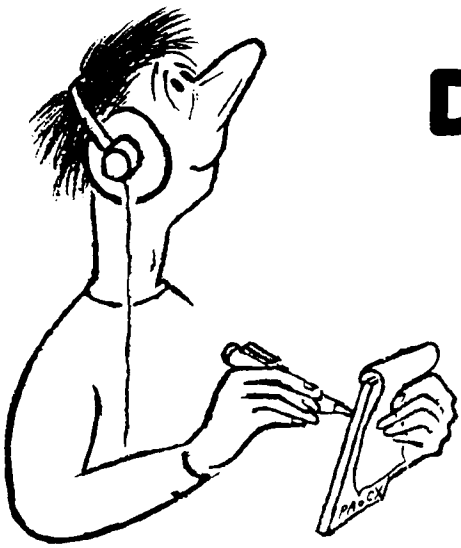
- Deviation—R112—located near the front center of the main board
- Low Power—R149—located to the right of R112
- Mic Gain—R132—located near the front of the main board near the right side
- Power Meter—R73—located near the back of the radio in the shielded can
- S-meter—R23—located near the front center of the main board

Conclusion

I've gained a lot of experience over the years from servicing a number of these radios. A service manual is unavailable, and the owner's manual contains little information pertaining to serviceability. These changes and notes should help you fix some of the minor problems which can occur in an older radio.

*Icom USA verifies that no service manuals were printed for the IC22S. Schematics can be provided by Icom upon request. Ed.

Article K — **HAM RADIO**



DX FORECASTER

Gorth Stonehocker, KØRYW

High sunspot propagation problems: part 2

Events that originate with solar flares cause propagation problems for Dxers and ragchewers alike. A sequence of events happens after a flare. Some (like sudden ionospheric disturbance, SID) occur shortly after the flare, some (like polar cap absorption, PCA) appear several hours later, and the final event (fade out) occurs from 1 to 3 days following the flare. The first two situations and remedies for them were discussed last month. These events will occur more frequently with the increased probability of large flares as the 11-year solar cycle reaches higher sunspot numbers and solar flux; be prepared with a remedy.

Fade out

Fade out is the most complicated and encompassing of *all the* ionospheric disturbances. It can affect propagation paths during the day or night, but the effect is worse at night. It lasts at least a day or two and is generally worldwide in extent, although the effects and severity differ with latitude and longitude. Fade out is initially caused by the electrons that were ejected outward by the sun's flaring. These electrons are usually lower in energy than protons so they don't have the proton's speed, but they are more numerous. Being charged particles, the electrons are constrained to follow the solar magnetic field as they leave the sun. They travel with the solar wind, increasing its number density greatly and its speed a little. Those coming close enough to the earth's magnetic field veer into the polar regions along those magnetic field lines. Most of the electrons are high and weak enough to be fed into the geomagnetic field tail, captured, and then released at lower latitude into the ionospheric F region at night. It takes electrons some 1 to 3 days after the flare to affect the ionosphere due to their lower energy, the long solar path, and the delay caused by the earth's capturing some to release at night.

The latitude ion density distribution *in the F region* is normally at its highest in the equatorial latitudes from 30 degrees south to 30 degrees north. This is because the lower regions (D and E) are where the largest production of latitude ions from sunlight exists. When these ions drift to the F region up the field lines, the maximum density changes from its position along the geographic equator to one along the *geomagnetic equator. The* other ionospheric production region comes from the polar particles. Moving slightly toward the equator from the auroral zone (an area of no production) you'll find the F region trough, particularly on winter nights. However, when the electrons start coming "hard" into the E region or "soft" from the tail into the F region, the trough widens and moves down even more toward the equator. How does this affect propagation and DX? The propagation paths at midlatitudes in east-west directions, like the United States to Europe or the Orient, go across higher latitudes. When the particles arrive, the auroral oval and trough come down right across your path, and the fade out has hit. Two things happen: the increase in the number of particles weakens the signal trying to get through, and the trough's lower density causes a decrease in maximum usable frequency (MUF). These decreases are not smooth, but variable (in seconds/minutes), and fluctuate over the 2 or 3 day period. The one difference between SID and fade out is that SID has a smoother decrease. The K figure broadcast at 18 minutes after the hour over radio station WWV is a measure of the geomagnetic-field ionosphere variations compared to the normal 3 hours of the day. It can be used to calibrate a path during nondisturbed periods which is used, in turn, to forecast how bad the propagation is when a fade out occurs. Fade outs from flares are more intense but of shorter duration than those from thin coronal solar wind increases.

The weak, variable signal strength and decreased MUF are hard to remedy. Ordinarily, the weak signal remedy for absorption is to increase the operating frequency as you would in the SID's remedy. But here MUF is decreasing on the propagation path, which calls for decreased operating

WESTERN USA

GMT	PDT	N	NE	E	SE	S	SW	W	NW
0000	5:00	20	30	20	10	12*	12	10	15
0100	6:00	20	30	20	12	12	10	10	15
0200	7:00	20	40	20	12	12	10	10	15
0300	8:00	20	*40*	20	15	15	10	12	15
0400	9:00	30	*40*	*20*	15	15	12	12	20
0500	10:00	30	*40*	*20*	*20*	15	12	15	20
0000	11:00	30	*40*	*20*	*20*	20	15	15	20
0700	12:00	30	30	*20*	*20*	20	15	20	20
0800	1:00	30	*40*	*20*	*20*	20	15	20	20
0000	2:00	30	*40*	*20*	*20*	20	15	20	30
1000	3:00	*40*	*40*	*20*	*20*	*20*	15	20	*30*
1100	4:00	*40*	*40*	*20*	*15*	*30*	20	*20*	*30*
1200	5:00	*40*	30	15	15	*30*	*20*	*20*	*30*
1300	6:00	*40*	20	12	15	*30*	*20*	*20*	*30*
1400	7:00	30	20	12	12	*30*	*20*	*20*	*30*
1500	8:00	30	15	10	12	20	*20*	20	*30*
1600	9:00	30	20	10	10	15	*20*	*20*	*30*
1700	10:00	30	20	10	10	15	*20*	*20*	*30*
1800	11:00	30	20	10	10	12	15	20	30
1900	12:00	*40*	20	12	10	12	15	15	20
2000	1:00	*40*	30	12	10	12	15	15	20
2100	2:00	*40*	30	15	10	12	12	15	20
2200	3:00	*40*	30	15	10	12*	12	12	15
2300	4:00	20	30	15	10	12*	12	12	15

MID USA

MDT	N	NE	E	SE	S	SW	W	NW	CDT
6:00	20	30	20	12	12	10	10	20	7:00
7:00	20	40	20	15	15	12	10	20	8:00
8:00	30	40	20	15	15	12	12	30	9:00
9:00	30	*40*	*20*	15	15	15	12	30	10:00
10:00	30	*40*	*20*	20	15	15	15	30	11:00
11:00	30	*40*	*20*	20	20	15	15	30	12:00
12:00	30	*40*	*20*	*20*	20	15	15	30	1:00
1:00	30	30	*20*	*20*	20	15	20	30	2:00
2:00	*40*	*40*	*20*	*20*	20	20	*20*	30	3:00
3:00	*40*	*40*	*20*	*20*	*20*	20	*20*	*40*	4:00
4:00	*40*	*40*	15	*20*	*30*	*20*	*20*	*40*	5:00
5:00	*40*	*40*	12	*15*	*30*	*20*	*20*	*40*	6:00
6:00	30	30	12	15	*30*	*20*	*20*	*40*	7:00
7:00	30	20	12	15	*20*	*20*	*20*	30	8:00
8:00	30	20	10	12	20	*20*	20	30	9:00
9:00	30	15	10	12	15	*20*	20	*40*	10:00
10:00	30	15	10	10	15	*20*	20	*40*	11:00
11:00	30	20	10	10	15	20	*20*	*40*	12:00
12:00	30	20	10	10	15	15	20	*40*	1:00
1:00	*40*	20	12	10	12	15	15	30	2:00
2:00	*40*	30	12	10	12	15	15	20	3:00
3:00	*40*	30	15	10	12	12	12	15	4:00
4:00	*40*	30	15	10	12	12	12	20*	5:00
5:00	20	30	15	10	12*	10	10	20	6:00

EASTERN USA

EDT	N	NE	E	SE	S	SW	W	NW
8:00	30	40	20	12	12	12	12	20
9:00	30	40	20	15	15	15	15	30
10:00	30	*40*	*20*	15	15	15	15	30
11:00	30	*40*	*20*	15	15	20	20	30
12:00	30	*40*	*20*	20	15	20	20	30
1:00	30	*40*	*20*	*20*	20	20	20	30
2:00	*40*	*40*	*20*	*20*	20	*20*	*20*	30
3:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*40*
4:00	*40*	*40*	*20*	*20*	*30*	*20*	*20*	*40*
5:00	*40*	20	20	*20*	*30*	*20*	*20*	*40*
6:00	20	20	12	*20*	*30*	*20*	*20*	*40*
7:00	20	20	12	15	*20*	*20*	*20*	30
8:00	20	15	12	15	20	20*	15	30
9:00	20	15	10	15	15	20	15	30
10:00	30	15	10	12	15	20	20	30
11:00	30	15	10	12	15	*20*	20	*40*
12:00	30	15	10	10	15	20	20	*40*
1:00	30	20	10	10	15	15	*20*	*40*
2:00	30	20	10	10	15	15	20	*40*
3:00	30	20	12	10	12	15	15	30
4:00	*40*	30	12	10	12	12	12	20
5:00	*40*	30	15	10	12	12	12	20*
6:00	*40*	30	15	10	12	10	10	20*
7:00	*40*	30	15	12	12	10	10	20

OCTOBER

	N	NE	E	SE	S	SW	W	NW
ASIA FAR EAST	20	30	20	10	12*	12	10	15
EUROPE	20	30	20	12	12	10	10	15
S. AFRICA	20	40	20	12	12	10	10	15
S. AMERICA	20	*40*	20	15	15	10	12	15
ANTARCTICA	30	*40*	*20*	15	15	12	12	20
NEW ZEALAND	30	*40*	*20*	*20*	15	12	15	20
OCEANIA AUSTRALIA	30	*40*	*20*	*20*	20	15	15	20
JAPAN	30	30	*20*	*20*	20	15	20	20
ASIA FAR EAST	30	*40*	*20*	*20*	20	15	20	20
EUROPE	30	*40*	*20*	*20*	20	15	20	30
S. AFRICA	*40*	*40*	*20*	*20*	20	20	*20*	30
S. AMERICA	*40*	*40*	*20*	*20*	*20*	20	*20*	*40*
ANTARCTICA	*40*	*40*	15	*20*	*30*	*20*	*20*	*40*
NEW ZEALAND	*40*	*40*	12	*15*	*30*	*20*	*20*	*40*
OCEANIA AUSTRALIA	30	30	12	15	*30*	*20*	*20*	*40*
JAPAN	30	20	12	15	*20*	*20*	*20*	30
ASIA FAR EAST	30	20	10	12	20	*20*	20	30
EUROPE	30	15	10	12	15	*20*	20	*40*
S. AFRICA	30	15	10	10	15	*20*	20	*40*
S. AMERICA	30	20	10	10	15	20	*20*	*40*
ANTARCTICA	30	20	10	10	15	15	20	*40*
NEW ZEALAND	40	20	12	10	12	15	15	30
OCEANIA AUSTRALIA	40	30	12	10	12	15	15	20
JAPAN	40	30	12	10	12	15	15	20
ASIA FAR EAST	40	30	12	10	12	12	12	20
EUROPE	40	30	15	10	12	12	12	15
S. AFRICA	40	30	15	10	12	12	12	20
CARIBBEAN S. AMERICA	40	30	15	10	12	12	12	20*
ANTARCTICA	40	30	15	10	12	10	10	20*
NEW ZEALAND	40	30	15	12	12	10	10	20
OCEANIA AUSTRALIA	40	30	15	12	12	10	10	20
JAPAN	40	30	15	12	12	10	10	20

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next higher band for possible openings.

frequency. You can try a combination of the two to determine which part of the problem is worse and go from there, or try VHF frequencies that may be getting through on auroral scatter. An alternate route south of the usual beam bearing (called side scatter at hf) may work, or long-path propagation may exist.

Last-minute forecast

The lower bands, 30 to 160 meters, are expected to be best the first and third weeks of October due to a dip in solar flux. Lower thunderstorm noise and summer absorption in the Northern Hemisphere will make a noticeable improvement in these bands. Expect some fade out to affect propagation during this equinox season around the 6th, 16th, 22nd, and 28th. The higher DX bands should improve the second week and be best the third week, as the result of a solar flux increase. Watch out for flare effects, SID, and PCAs during this activity. The Orionids meteor shower will be visible from the 15th to 24th of October, with a maximum rate of between 10 to 20 per hour on the 20th to 21st of the month. The moon is full on the 25th and perigee occurs on the 23rd.

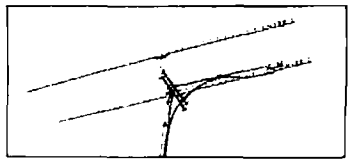
Band-by-band summary

Ten, 12, 15, and 20 meters will provide many openings during the day. As you go up in frequency the openings will be shorter, centered around noon, and mainly towards the south. Twenty meters, the mainstay daytime band for northerly directions, will be useful towards the south in the evenings. Transequatorial openings might occur in the evening hours to southern locations if antenna radiation angles are down to 10 degrees.

Thirty, 40, 80, and 160 meters are all good for nighttime DX. Thirty and 40 meters are the night frequencies for the east, west, and northerly directions, and for distances of 1600 miles. Try 80 and 160 if disturbed conditions exist. These bands should be getting quiet, if fall weather frontal thunderstorms are absent.

Article L **HAM RADIO**

DOWN EAST MICROWAVE



MICROWAVE ANTENNAS AND EQUIPMENT

• Loop Yagis • Power Dividers • Linear Amplifiers • Complete Arrays • Microwave Transverters • GaAs FET Preamps • TROPO • EME • Weak Signal • OSCAR • 902 • 1269 • 1296 • 2304 • 2400 • 3456 MHz

2345 LY	45el	loop Yagi	1296 MHz	20dBI	$97
1345 LY	45el	loop Yagi	2304 MHz	20dBI	$84
3333 LY	33el	loop Yagi	902 MHz	18.5dBI	$97

Above antennas assembled and tested. Kits available.

Add $8 UPS S/H, $11 West of the Mississippi

MICROWAVE LINEAR AMPLIFIERS SSB, ATV, REPEATER, OSCAR

2318 PA	1w in 18w out	1240-1300 MHz	13.8V	$255
2335 PA	10w in 35w out	1240-1300 MHz	13.8V	$305
3318 PA	1w in 20w out	900-930 MHz	13.8V	$255
3335 PA	10w in 40w out	900-930 MHz	13.8V	$305
23LNA preamp 0.7dB N.F.		1296 MHz		$ 80
33LNA preamp 0.9dB N.F.		902 MHz		$ 80

Add $5 shipping UPS/48

LMW 1296 & 2304 MHz transverter kits in stock

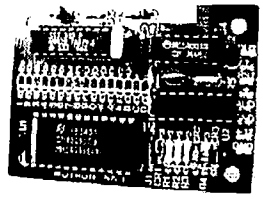
Write for free catalog

VISA

DOWN EAST MICROWAVE
Bill Olson, W3HQT
Box 2310, RR 1, Troy, ME 04987
(207) 948-3741

✓ 172

NET-KALL NK-1
DTMF ALERT DECODER



From Only **$34.95!**

- Momentary or latched output
- Multiple Group-Call response
- High stability xtal controlled SSI-202
- Ideal for an economical alert system

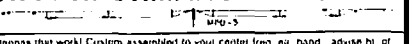
VISA

NK-1K (kit) $34.95
NK-1W (Wired/Tested) $44.95
(Add $2.00 Shipping/Handling in U.S.A.)

MoTron Electronics *Call Toll-Free*
695 W. 21st Ave **1-800-338-9058**
Eugene, OR 97405 or (503) 687-2118

✓ 173

HI-PERFORMANCE DIPOLES



Antennas that work! Custom assembled to your center freq. ea. band - advise ht. of center and each end - hang as inverted "V" - horizontal, vert. dipole, sloping dipole - commercial quality - stainless hardware - legal power - no-trap, high efficiency design. Personal check, MO or C.O.D. ($3)

MPD-5*	80-40-20-15-10M max-performance dipole 87' long	$105ppd
MPD-2	80-40M max-performance dipole, 85' long $62	95'-$88 ppd
HPD-3*	160-80-40M hi-performance dipole 113' long	$79 ppd
SSD-6*	160-80-40-20-15-10M space saver dipole 71' long	$125 ppd
SSD-5*	80-40-20-15-10M space saver dipole-specify L. 42'-$105	52'-$108 ppd
SSD-4*	80-40-20-15M space saver dipole-specify L. 46'-$93	80'-$ 96 ppd

*9-bands with wide-matching-range tuner.

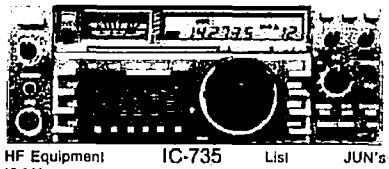
SASE for catalogue of 30 dipoles, slopers, and space-saving, unique antennas

WYNN ANTENNAS
312-394-3414 BOX 393 MT. PROSPECT, IL 60056

✓ 174

800-882-1343

ICOM



HF Equipment IC-735	List	JUN's
ICOM		
IC-781 Now Deluxe HF Rig	$5995	Call $
IC-761 Loaded with Extras	2699	Call $
IC-735 Gen. Cvg Xcvr	1099	Call $
IC-751A Gen. Cvg Xcvr	1699	Call $
Receivers		
IC-R7000 25-1300¹ MHz Rcvr	1199	Call $
IC-R71A 100 kHz-30 MHz Rcvr	999	Call $
VHF		
IC-228A/H	509/539	Call $
IC-28A/H FM Mobile 25w/45w	469/499	Call $
IC-02AT FM HT	409.95	Call $
IC-2GAT 2m 7w HT	429.95	Call $
IC-900 Six Band Mobile	639	Call $
UHF		
IC-48A FM Mobile 25w	509	Call $
IC-04AT FM HT	449	Call $
IC-4GAT 440MHz HT	429.95	Call $
220 MHz		
IC-38A 25w FM Xcvr	489	Call $
IC-32AT 2m/70cm HT	629.95	Call $

KENWOOD

KENWOOD		
HF Equipment		
TS-940S/AT Gen. Cvg Xcvr	2449.95	Call $
TS-440S/AT Gen. Cvg Xcvr	1379.95	Call $
TS-140S Compact Gen. Cvg Xcvr	929.95	Call $
VHF		
TS-711A All Mode Base 25w	1029.95	Call $
TR-751A All Mode Mobile 25w	649.95	Call $
TM-221A 2m 45w	439.95	Call $
TM-2550A FM Mobile 45w	499.95	Call $
TM-2570A FM Mobile 70w	599.95	Call $
TH-215A 2m HT Has It All	379.95	Call $
TH-25AT 5w Pocket HT NEW	349.95	Call $
TM-721A 2m/70cm FM Mobile	649.95	Call $
UHF		
TM-421A Compact FM 35w	449.95	Call $
TH-45AT 5w Pocket HT NEW	369.95	Call $
220 MHz		
TM-3530A FM 220 MHz 25w	499.95	Call $
TM-321A Compact 25w Mobile	449.95	Call $
TH-315A Full Featured 2.5w HT	399.95	Call $

YAESU

YAESU		
HF Equipment		
FT-767 GX Gen. Cvg Xcvr	1929.95	Call $
FT-757 GX II Gen. Cvg Xcvr	1129.95	Call $
FT-747 GX New Economical Performer	889.95	Call $
FL-7000 15m-160m AMP	1995.00	Call $
VHF		
FT-212RH NEW 2m 45w	459.95	Call $
FT-712RH 70cm 35W	499.95	Call $
FT-290R All Mode Portable	599.95	Call $
FT-23 R/TT Mini HT	344.95	Call $
FT-209RH FM Handheld 5w	389.95	Call $
VHF/UHF Full Duplex		
FT-736R, New All Mode 2m/70cm	1749.95	Call $
Dual Bander		
FT-727R 2m/70cm HT	439.95	Call $
FT-109RH New HT	399.95	Call $

JUN'S ELECTRONICS

3919 Sepulveda Blvd.
Culver City, CA 90230
213-390-8003

✓ 175



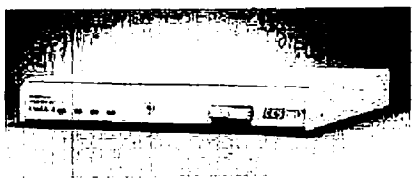
(continued from page 42)



- Call channel function. A special memory channel for each band stores frequency, offset, reverse, and sub-tone of your favorite channel.
- Balance control and separate squelch controls for each band.
- Dual watch function allows 144 and 440 MHz receive simultaneously.
- Full duplex operation.
- CTCSS encode/decode selectable from front panel main knob or UP/DOWN keys on microphone. (Includes built-in, optonal TSU-6 needed for decode.)
- Each function key has a unique tone for positive feedback.
- Handset/remote control option (RC-10).
- Dual antenna ports.
- Programmable memory andband scanning, with memory channel lock-out and priority watch function.
- Dimmer control.
- 16 key DTMF mic included.
- Supplied accessories: 16-key DTMF hand mic, mic hook, mounting bracket, DC cable.

The suggested retail price of the TM-621-A is $699.95.

For information contact your nearest Authorized Kenwood Dealer or Kenwood USA Corporation, 2201 E. Dominguez Street, Long Beach, California 90810.



New CES autpatch with repeater controller

Communications Electronics Specialties, Inc. has a new model 510SA-II telephone autopatch for Amateur Radio fixed station and repeater applications. The 510SA-II is a full-featured microprocessor-controlled automatic telephone interconnect system that can be configured to operate in a simplex sampling mode for Amateur VHF or UHF fixed stations. It can also be used at the repeater site in a half or full duplex mode for mobile initiated calls.

Other features include: multi-digit DTMF connect code, activity timers, time out timers, CW ID, toll restrict and disconnect override code — all programmable by use of any DTMF telephone with a special security access code In addition, remote base station operation is enabled by special security code, repeater logic control is provided for making a repeater with autopatch capability out of two transceivers, and the unit is reverse-patch capable with automatic ringout upon receipt of an inbound call.

Additional information on the 510SA-II autopatch or other CES DTMF microphones, interconnects, and accessories is available by contacting CES, 931 S. Semoran Boulevard, Suite 218, Winter Park, Florida 32792.

Circle #305 on Reader Service Card.

Auto-kall—HF alert

The MoTron Auto-Kall HF-Alert is a selective calling or alerting system designed for use with HF SSB/CW Amateur Radio. It also works on VHF/UHF SSB/CW, CB, and marine HF/VHF.



The encoder sends two strings of "dits" at a precise, crystal-controlled speed. The decoder mutes the speaker until the correct calling sequence is received. This turns on the internal (or external) speaker for an adjustable time period, sets a red call LED, and enables an alarm output. There are 225 possible code combinations. The calling/decoding codes are set via rotary switches accessible through the front panel.

HF-Alert comes with mobile mounting bracket, 117-VAC power supply for base operation, and an audio patch cord. Use the built-in speaker or an external one. Send the calling signal by keying a CW transmitter or placing the microphone next to the speaker.

The HF-Alert is available from MoTron Electronics, 695 W. 21st Avenue, Eugene, Oregon 97405 for $129.95.

Circle #306 on Reader Service Card.

New portable spectrum analyzer—PSA-37D

AVCOM introduces its PSA-3D Portable Spectrum Analyzer. Frequency coverage is from less than 10 to over 1750 MHz, and from 3.7 to 4.2 GHz in 5 bands. Frequency readout is shown in MHz on a four-digit LCD front panel display.

The PSA-37D has a built in dc block with +18 Vdc for powering LNA's and BDC's, calibrated signal strength amplitude display, and internal battery with charger. Selectable vertical sensitivity of either 2 dB or 10 dB/DIV is standard. It is battery or line operated.

For more information write to AVCOM of Virginia Incorporated, 500 Southlake Blvd., Richmond, Virginia 23236

Circle #307 on Reader Service Card.

IMCT for XT/AT

AC3L Software announces its IMCT (international morse code trainer) for XT/AT compatible computers. The IMCT:

- Is menu driven with adjustable pitch and speeds of 1-20+ wpm.
- Has step-by-step beginner instructions — starting with sound recognition, it works through each code character.
- Allows keys to be typed and code heard; the keyboard can be used as a straight key. Computer tests are generated either by the computer (random) or from ASCII text files which can be read by IMCT and sent as entered or in random order.
- Has a built-in on-screen ham radio to tune around and practice copy.

The IMCT requires DOS 2.1 or later and at least 256 K of RAM and sells for $39.95 (shipping included, US funds only) for a 5-1/4 or 3-1/2 inch diskette. Pennsylvania residents add 6 percent.

For more information contact AC3L Software, Box 7, New Derry, Pennsylvania 15671.

Circle #308 on Reader Service Card.

Voice box for dx'ers and contesters

QRZ Industries announces the Voice Box and the Mini Voice Box, two stand-alone operating acessories for DX'ers and contesters. The Voice Box digitizes and stores an operator's own natural voice. Once stored, a voice message can be instantly recalled to call CQ or repeat any other phrase.

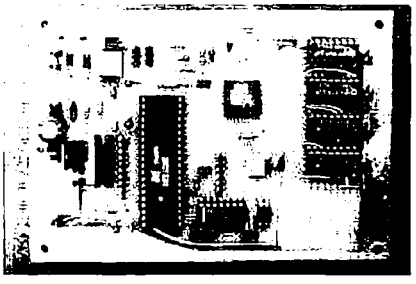
You can record a total of 8 different phrases and operator voices for a total of 32 seconds. A voice message can be played back once at the touch of a button (or footswitch), or repeatedly with an adjustable pause between messages. If a response is received, the Voice Box aborts repeated playback until prompted to start again. When a voice message is deleted, the memory it used is freed up to record new phrases; all the other existing voice messages are preserved.

The Voice Box uses a 32-kHz sampling rate and several filters for high-quality audio. It automatically keys the PTT line to your transmitter or transceiver during playback, and also allows

(continued on page 105)



(continued from page 102)



normal VOX operation. It has a switchable built-in microphone preamp to accomodate a wide variety of microphones and the audio output level to the transmitter is continuously adjustable. The Voice Box can be powered from a 10 to 16-Vdc source.

The Mini Voice Box has all the features of the regular Voice Box except that it has one voice message channel with up to 8 seconds of message time.

The Voice Box and the Mini Voice Box are shipped in kit form only. The kits consist of assembled, tested, working boards with complete instructions for installing the board in a suitable enclosure. Some standard offboard components (pushbuttons, toggle switches, microphone and power connectors, etc.) are required to complete the unit. They are available as an option.

Due to the current RAM shortage, Voice Box boards are being shipped without memory. Four plug-in 41256 (any speed) RAM chips are required to make the Voice Box operational. (The Mini Voice Box takes one.)

The introductory price of the Voice Box kit is $95. The Mini Voice Box kit price is $55. The offboard components option runs $20 for the Voice Box and $10 for the Mini Voice Box. To order send check, money order, or C.O.D. to QRZ Industries, P.O. Box 160, Piedmont, South Carolina 29673. Add $10 for shipping and handling, and $5 for C.O.D. orders. South Carolina residents add 5 percent sales tax. Please state name of publication where seen when placing order or requesting information.

Circle #313 on Reader Service Card.

Computerized DXing with software for IBM PC/XT/AT

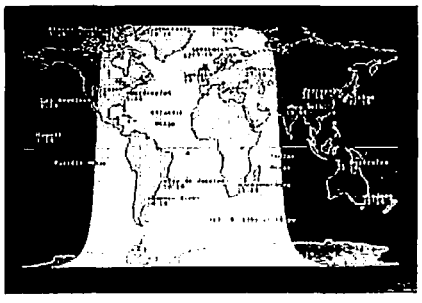
The new MFJ-1286 Gray Line DX Advantage/Terminator is a computerized DXing tool that predicts DX propagation by giving users instant access to Gray Line positions for any place in the world, at any time and date from 1980 to 1999.

You get a high resolution world map that displays the Gray Line as a moving area of day and night which changes with time. It shows you the moving Gray Line, UTC times, time zones, sun position over the earth, and latitude/longitude markers.

You can customize the MFJ-1286 Gray Line DX Advantage and display time and location for any QTH in the world. Run it by itself or as a memory resident program, in conjunction with your beam header or other software. It works with all graphics: Hercules, CGA, EGA and composite.

It comes with three maps: a default Land Mass Map, a map that shows the latitude/longitude markers, and a third map that displays the division of time zones throughout the world. CGA works with the Landmass Map and lets you send the display to your printer.

It also corrects for the north/south position of the sun and the curvature of the earth, making it perhaps the most accurate Gray Line predictor yet.



Pressing a function key switches the new MFJ-1286 Gray Line DX Advantage to a high speed display mode. This lets you watch solar and Gray line positions change in increments of 2 minutes, 6 minutes, 1 hour, 1 day, or 1 week. You can also pause the high speed display to study a position.

The MFJ-1286 retails for $29.95 and is available from any MFJ dealer or direct from MFJ Enterprises Inc.

For more information contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

Circle #314 on Reader Service Card.

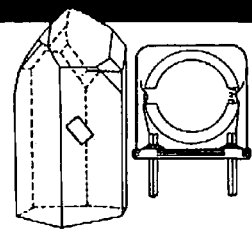
Universal M-7000: new communications terminal

Universal Shortwave offers an exciting new product — the Universal M-7000 military-grade communications terminal. This self-contained device connects to the audio output of any quality communications receiver. Output is to a video

(continued on page 106)

When performance & price really count..
CRYSTEK CRYSTALS
The pulse of dependable communications

Reliability & Quality
From Start To Finished Product

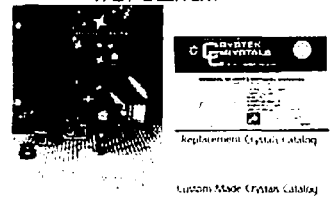


QUARTZ
CRYSTALS/OSCILLATORS FOR
ELECTRONIC — INDUSTRIAL
- Micro-Processor Control
- Computers/Modems
- Test/Measurement
- Medical

COMMUNICATIONS — REPLACEMENT
- Mobile/2-way/Channel Elements
- Pagers
- Marine
- Aircraft
- Telemetry
- Monitors/Scanners

AMATEURS
- CB
- Hobbiest
- Experimenter

COST EFFECTIVE
MODERATE PRICING
FAST DELIVERY



The Pulse of Dependable Communications
Crystek Crystals offers their new 16 page FREE catalog of crystals and oscillators. Offering state-of-the-art crystal components manufactured by the latest automated technology. Custom designed or "off the shelf." Crystek meets the need, worldwide. Write or call today!

CRYSTEK CORPORATION
DIVISION OF WHITEHALL CORPORATION
2351/2371 Crystal Dr. • Ft. Myers, FL 33907
P.O. Box 06135 • Ft. Myers, FL 33906-6135
TOLL FREE 1-800-237-3061
(813) 936-2109 — TWX 510-951-7448

SPEED-X SERVICE

179



(continued from page 105)

monitor (serial and parallel printer ports are also provided). The M-7000 decodes and displays all standard transmission modes: Morse code; Baudot, ASCII, Packet and Sitor A and B. Less common modes such as bit-inverted Baudot, high speed ASCII, ARQ-Moore (TDM), and Frequency Division Multiplex (FDM-VFT) are also supported. Other special display modes include Russian Third Shift Cyrillic, Literal, and Databit mode. The M-7000 also prints high quality facsimile (FAX) images to the parallel printer port.

Microprocessor controlled, switched capacitor filters comprise the prefilters, the channel filters, and the post detection low pass filter.

The M-7000 offers advanced monitoring features including: diversity inputs, split screen ARQ, remote terminal control, speed readout, screen saver, screen print, ten memories, Sel-Cals, auto-start, and screen print. Automatic filter tuning and auto-tune features provide semi-automated operation for maximum convenience.



The M-7000 is manufactured in Englewood, Florida by Digital Electronic Systems. Available factory installed options include a Real Time Clock and a Video FAX option. The M-7000 is available from stock at Universal and other selected dealers.

For additional information contact Universal Shortwave Radio, 1280 Aida Drive, Reynoldsburg, Ohio 43068.

Circle #315 on Reader Service Card.

New personal-scanning receiver offers 100 channels and all-band coverage

AOR, Ltd. has introduced of a new 100-channel hand-hald receiver that offers complete public service band coverage.

The new radio measures 5-3/4" x 2-1/8" x 1-3/4". The receiver's frequency coverage is: 27-54 MHz, 108-174 MHz, 406-512 MHz, and 830-950 MHz. This allows coverage of all the police, fire and emergency bands, plus the new services now available above 800 MHz in 12.5, 25, and 30 kHz increments.



At 12 ounces total weight the model AR900 can be carried in a pocket, with the standard belt clip, or in an optional leather carry case.

Twenty-five front panel keys allow programming of five banks of 20 channels. Pairs of upper and lower limits for bands to be searched can be stored in 5 separate search memory locations. Information is stored in three permanent memories, which never lose program information should the batteries be disconnected. Extra features include first channel priority, keyboard lockout, BNC antenna connector, and a blue-green display backlight for night use. The LCD display offers 22 separate prompting annunciators.

The suggested retail price is $299. This includes a 450 MAH rechargeable battery, ac charger/adaptor, two antennas, and a stainless steel belt clip.

For further information contact ACE Communications, Monitor Division, 10707 East 106th Street, Indianapolis, Indiana 46256.

Circle #316 on Reader Service Card.

CS64W Connect-A-Call Telephone repeater

Engineering Consulting's "Connect-A-Call" (a telephone repeater) that is a cartridge for the Commodore (C-64, C-64C, C-128) computer. The cartridge works in three modes.

Mode #1 allows access to your Watts line from any phone — including cellular. It has multi-user options with multiple access codes and a logging option to provide usage time, and number dialed.

Mode #2 connects incoming calls to other telephone numbers if there is no answer after a preset number of rings. It can be remotely reprogrammed to change message, ring count, access codes, and delays.

Mode #3 re-directs incoming calls manually or automatically via access code, to as many as 1000 numbers.

The telephone repeater is dual amplified, and is powered by the computer. Connect-A-Call is available for $399.95 from Engineering Consulting, 583 Candlewood St. Brea, CA 92621

New database provides high-speed device selection

Motorola has introduced the Motorola Data Disk: Discrete Semiconductor Version. This IBM PC-compatible (384K RAM required) high-performance database permits rapid automated search and selection of Motorola's entire discrete semiconductor portfolio. The high-density selector guide contains 58 product categories with technical information for over 7,200 devices, 20,000 cross references, over 200 standard package types, and 130,000 parameters. It supports both part number and parametric searches.

The Discrete Data Disk provides Sales Office and Distributor information for hundreds of Motorola worldwide locations, support for five languages, user color support (including monochrome), a printer utility, help screens, an information request form, and "smart" message lines. The disk also includes toggles allowing selection across surface mount devices only, military devices only, or surface mount military devices only. The message lines use the "progressive disclosure" technique eliminating the need for a user's manual.



Within the next year, the capabilities of the Data Disk will be expanded to include parametric information for all 30,000-plus Motorola Semiconductor products (ICs as well as Discretes), complete with cross references and prices.

Copies of the Motorola Discrete Semiconductor Data Disk are available for $2.00 each by requesting DK101/D REV 1 from the Motorola Semiconductor Literature Distribution Center, P.O. Box 20912 Phoenix, Arizona 85036. The Data Disk is also available to Motorola customers through their local Motorola Semiconductor Sales Offices.

Circle #317 on Reader Service Card.

PI NETWORK
CAPACITOR EQUATIONS

Mason A. Logan, K4MT, 1607 Monmouth Drive, Sun City Center, Florida 33570

Self-sufficient equations use no intermediate steps

The versatile **Pi network** couples transmitter output stages to antennas while acting not only as a transformer, but as a filter and antenna tuner. It is a "conjugate impedance" network.[1] The first step for determining the network frequency response and the limits of the antenna tuning range (for either analysis or design) requires equations for each of the reactive elements. There are many articles on Pi networks with various procedures for determining the required network reactances.[2-7] Two new equations presented here for the shunt capacitors are self-sufficient and use no intermediate steps or square root factors.

Pi network circuit

Figure 1 is an apparatus diagram for a Pi network. It shows the terminations and reactive elements, with definitions for the resonant frequency impedances of each. **Figure 2** shows these impedances in a circuit with a resistive match to the transmitter and load resistances. Definitions are included for capacitor element Q's and the "operating Q" to aid in circuit analysis.

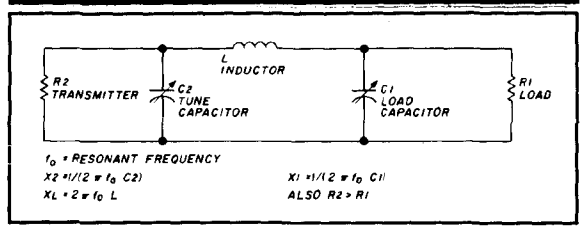
There are three reactive elements, a series inductor and two shunt capacitors. As stated above, the circuit is a conjugate impedance network. At the resonant frequency, the resistive transmitter output stage and the equivalent parallel resistance of the antenna load are exactly matched by the network's terminal impedance, as shown in **fig. 1**.

The application of the conjugate impedance condition to the general circuit equations results in the development of a fourth factor, the operating Q. Choosing this gives you a measure of control over the design. Q_{3dB} is always less than one-half of Q_O. Equations relating the above four factors are the subject of this article. Their derivation is given in the appendix.

The three equations

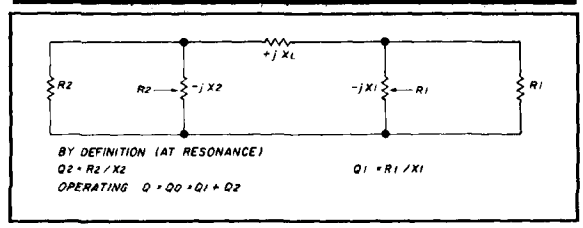
There are three equations, two of them new. The known equation[2,3] contains the dependency between Q_O and the inductive reactance X_L. This third equation can be arranged as a solution for either Q_O or X_L; each depends on the other. Given Q_O, there is only one inductive reactance X_L that goes with it, and vice versa. It should be obvious which of the two arrangements to use. The known equation plus the two others complete the set of equations to be calculated.

FIGURE 1



Pi-network apparatus diagram.

FIGURE 2



Pi-network circuit schematic.

First choose either Q_O or X_L; then calculate the other. If X_L is given:

$$Q_O = \frac{(R_1 + R_2) + 2\sqrt{R_1 R_2 - X_L^2}}{X_L} \qquad (1)$$

If Q_O is given:

$$X_L = \frac{Q_O(R_1+R_2) + 2\sqrt{R_1R_2Q_O^2 - (R_2-R_1)^2}}{Q_O^2+4} \quad (2)$$

With Q_O and X_L established, the two new symmetrical capacitor equations are:
Load:

$$X_1 = \frac{2R_1}{Q_O - \frac{(R_2-R_1)}{X_L}} \quad (3)$$

Tune:

$$X_2 = \frac{2R_2}{Q_O + \frac{(R_2-R_1)}{X_L}} \quad (4)$$

With nominal conditions, Q_O would be chosen somewhere between 10 and 20. This calls for the use of **eqn. 2** to determine the associated inductive reactance X_L. The load capacitor X_1 and the tune capacitor X_2 follow.

For another circuit (some other load condition, for instance) X_L is now fixed and you'll need to determine the changed Q_O. **Equation 1** is indicated in this situation.

For either circumstance, with a paired Q_O and X_L defined, **eqns. 3** and **4** directly determine X_1 and X_2 for the two capacitors.

For example, assume the transmitter R_2 is 5000 ohms, the antenna 50 ohms, and that a Q_O of 15 has been chosen. Then:
Q_O = 15
X_L = 379.99 ohms
X_1 = 50.67 ohms
X_2 = 356.80 ohms

Suppose that the load R_1 is changed to 100 ohms with a SWR of 2, and that X_L just determined is fixed. Then:
X_L = 379.99 ohms
Q_O = 16.56
X_1 = 54.57 ohms
X_2 = 339.50 ohms

There is only about a 6-percent change in the calculated factors when the load is resistive; for reactive loads the change is greater.[2]

Appendix

Derivation of the new equations for the two capacitors in the Pi network begins with two known equations[2,8]. These equations have the disadvantage of using square roots:

$$X_1 = \frac{R_1X_L}{R_1 + \sqrt{R_1R_2 - X_L^2}} \quad (5)$$

$$X_2 = \frac{R_2X_L}{R_2 + \sqrt{R_1R_2 - X_L^2}} \quad (6)$$

Divide both sides of **eqn. 5** by R_1 and both sides of **eqn. 6** by R_2. Invert both and use the definition of Q_1 and Q_2 to obtain:

$$Q_1 = \frac{R_1 + \sqrt{R_1R_2 - X_L^2}}{X_L} \quad (7)$$

$$Q_2 = \frac{R_2 + \sqrt{R_1R_2 - X_L^2}}{X_L} \quad (8)$$

The sum of **eqns. 7** and **8** is Q_O, agreeing with **eqn. 1** given earlier. The difference is the compact equation:

$$Q_2 - Q_1 = \frac{R_2 - R_1}{X_L} \quad (9)$$

Adding and subtracting this to the equation $Q_O = Q_1 + Q_2$ gives:

$$Q_1 = \frac{1}{2}\left(Q_O - \frac{R_2 - R_1}{X_L}\right) \quad (10)$$

$$Q_2 = \frac{1}{2}\left(Q_O - \frac{R_2 - R_1}{X_L}\right) \quad (11)$$

Finally, inserting the definitions of Q_1 and Q_2 in terms of their impedances, the capacitative reactances at the resonant frequency are:
Load:

$$X_1 = \frac{2R_1}{Q_O - \frac{R_2-R_1}{X_L}} \quad (12)$$

Tune:

$$X_2 = \frac{2R_2}{Q_O + \frac{R_2-R_1}{X_L}} \quad (13)$$

completing the derivation of the new pair of equations.

references

1. Walt Maxwell, W2DU, "Technical Correspondence", *QST*, March 1985, page 45.
2. Earl W. Whyman, W2HB, "Pi Network Design and Analysis," *ham radio*, September 1977, page 30.
3. Elmer A. Wingfield, W5FD, "New and Improved Formulas for the Design of Pi and Pi-L Networks," *QST*, August 1983, page 23.
4. Chris Bowick, WD4C, "Impedance Matching-A Brief Review," *ham radio*, June 1984, page 48.
5. William Orr, W6SAI, *Radio Handbook*, 22nd edition, Howard W. Sams, 1981, page 11-33.
6. *ARRL Radio Amateur Handbook*, 1984, page 2-48 and 2-49.
7. *ITT Reference Data for Radio Engineers*, 5th edition, Howard W. Sams, 1974, page 11-5.
8. W. L. Everitt, *Communication Engineering*, 2nd edition, McGraw-Hill, 1937.

Article M **HAM RADIO**



ELMER's NOTEBOOK

Tom McMullen, W1SL

Modems and RS-232

Let's take another look at modems and also at RS-232, which is associated with computers, modems, and packet radio.

What is a modem?

Modem is a contraction of the words MOdulator/DEModulator, and it refers to a device that goes between a terminal (personal computer, keyboard, "dumb" terminal, etc.) and a radio transmitter/receiver. Before we get into the specifics of a modem's use with radios, let's look at another, earlier use of the device.

A simple communications circuit using data terminals and modems is shown in **fig. 1**. Modems are required because data pulses don't take kindly to cables that are longer than a few feet. The capacitance of such cables is placed effectively across the output of the terminals; this tends to distort the pulses and make them ineffective as signals between computers.

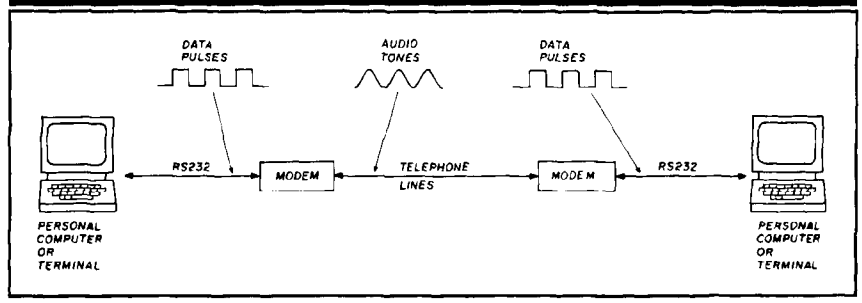
The modems overcome this limitation by translating the pulses into audio tones that aren't distorted by the long lines. Depending upon the transmission speed, the tone frequency changes according to the data pulse fed to the modem. When the pulse is at its low or zero state, the tone has one frequency; when the pulse changes to its high or 1 state, the frequency changes to something else. The difference between these two tones is called the "shift." There's nothing here that hasn't been done with RTTY, but computers do it faster.

This basic audio-frequency shift system is in common use at transmission rates up to perhaps 1200 bauds. At higher rates, another scheme called phase-shift keying is sometimes used. Here, the audio *frequency* does not shift, but the *phase* is shifted according to the state of the data pulse. Some advanced high-speed circuits use a mixture of both audio and phase-shift keying.

On a circuit that you might use to talk to another computer via your telephone lines, 300 or 1200 baud would be a common speed. Your terminal sends a stream of pulses to the modem. The modem then translates them into a tone that changes frequency in step with the pulses and feeds them into the telphone system. The telephone network treats the tones as if they were a voice and sends them to the modem at the other end. The receiving modem performs a reverse translation, detecting the shift in the tone frequencies and turning it into pulses just like the ones your terminal generated. These pulses are sent to the other terminal and interpreted as letters, numbers, or commands.

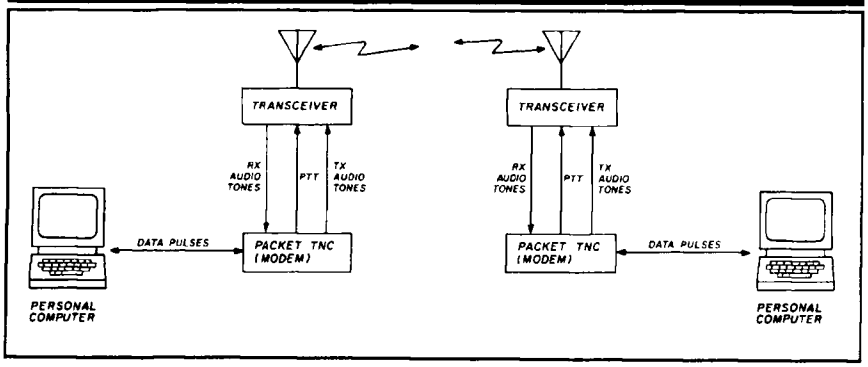
There are a few simple "handshake" procedures in operation in a system like that in fig. 1. First, your terminal needs to know that the modem is at the other end of the line, and ready to operate. It does this by checking to see if there is continuity in a circuit that goes to the modem and back. In essence, it puts a dc voltage on a wire,

FIGURE 1



A data-communications circuit that uses modems and a telephone line. The modems create and decode tones that are within the normal voice band of frequencies acceptable by the telephone system.

FIGURE 2



A packet-radio system. In addition to establising rf communications between the two transceivers, the modems perform many encoding, decoding, and housekeeping chores.

telling the modem "I'm ready to send." This is known as a Data Terminal Ready (DTR) signal. The modem, in turn, places a voltage on a wire that says, "I'm ready to receive." In this case, it's a Data Set Ready (DSR) signal. Once this handshake has been accomplished, things are ready to go. But wait a minute! What if the telephone line isn't working? In another handshake procedure, the modem first looks for a carrier (audio tone of the correct frequency) from the modem at the other end of the line. If it's not there, it won't send the DSR signal back to the data terminal. If the tone is detected, the DSR signal is sent and you're ready to transmit data — assuming that the modem and terminal at the other end have completed their handshake and are ready too.

The "alphabet soup" here can get pretty thick: Data Terminal Equipment (DTE), Data Communications Equipment (DCE), Carrier Detect (CD), Ready To Send (RTS), Clear To Send (CTS), and on and on. You needn't know all these terms unless you want to get into data communications in a big way. Many of these signals and procedures are taken care of automatically by the equipment and programs, but knowledge of them is helpful if you're designing or troubleshooting a system.

The packet-radio modem

At first glance, it might seem that you could simply remove the telephones and wire lines from the diagram in fig. 1, replace them with a transceiver and antennas, and have a packet-radio circuit as shown in fig. 2.

That's pretty close to the way it's done. The packet equipment, called a Terminal Node Controller (TNC), acts as a modem. It translates pulses into audio tones for transmitting, and does the reverse for receiving. However, the packet modem must have a lot more built-in "smarts". The modem does have some basic handshake systems, just like its land-line cousin, but the difference comes when you start using the packet rules called "protocols." For example, if you type the letter "H" on the keyboard in your land-line setup, it is translated into pulses (1's and 0's) by your terminal or computer. The modem then translates these pulses into tones and sends them out on the telphone line. At the other end, the modem translates the tones back to pulses; the terminal translates the pulses back to the letter H, and the letter appears on the screen. On a packet system, the TNC must first place the pulses that represent the letter H in a message form (the packet) that contains the correct address, along with information to check the accuracy of the message. The whole packet is then sent to the other station. The receiving station's TNC translates the tones into pulses and checks for errors. It then acknowledges receipt (if the message was received correctly), strips all the address and sender's identification out of the packet, and sends the pulses on to the terminal, where a letter will be displayed on the screen. If the receiving station finds an error, it doesn't acknowledge receipt. The transmitting station tries until it either gets an answer or times out.

Your packet modem also includes software that lets you tell it what stations you do or don't want to communicate with, what to monitor or not to monitor, what speed (baud rate) to use, and which relay stations to use if needed. Some will let you switch bands and operating modes in response to a command from the keyboard. Most TNCs also have the ability to check their own health and calibration ability, letting you look at messages to find where an error occurs. Many TNCs can be configured to repeat packets between other stations by simply entering a command from your terminal.

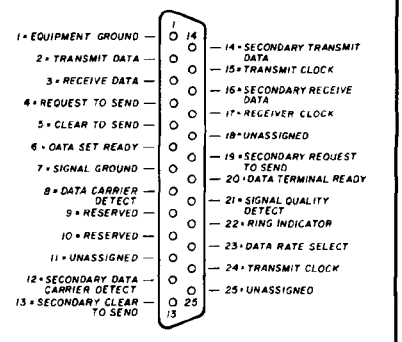
Basically, a TNC is a microprocessor-controlled modem with a tremendous amount of built-in software, making operation easier and more enjoyable. This takes you far beyond just keying a transmitter and listening for a reply. You could use a less sophisticated modem by building most of these features into the data terminal or computer software; some packet equipment/software suppliers have done just that. The end result is the same and the way to go is a matter of choice.

What's RS-232?

First, let me point out that the plug or connector on the end of a cable or a piece of equipment isn't an RS-232 connector in the true sense of the word. The connectors most commonly called RS-232 are actually DB-25 connectors, although other types have also been misnamed.

RS-232 is a set of standards for data signal transmission. Since the latest version is "C," the standard is referred to as "RS-232C." Basically, the standard defines the voltage levels that must appear on certain lines, what those lines are called, what lines are

FIGURE 3



A common connector for communications equipment is a DB-25 type, shown here with pins and RS-232C signals identified.

TABLE 1

The signals and voltage levels as described in the RS-232C standard. Not all of these are used in every piece of equipment.

Pin	RS-232C Name	Function and Description
1	AA	Protective ground or Equipment ground
2	BA	Transmitted Data: Mark = −3 to −25 volts; Space = +3 to +25 volts
3	BB	Received Data: Mark = −5 to −15 volts; Space = +5 to +15 volts
4	CA	Request To Send: Terminal asserts* this pin when it has data to transmit. It waits for Clear to Send before sending.
5	CB	Clear To Send: The Data Set asserts this in response to DTE if the set is ready.
6	CC	Data Set Ready: The modem (Data Set) asserts this line in response to DTR (pin 20) to show that it is on and operational.
7	AB	Signal Ground or Common Return. This can be connected to pin 1, but doing so may cause noise or ground-loop problems in some cases.
8	CF	Receive Signal Detector or Data Carrier Detect: The modem asserts this line when a correct carrier tone is detected.
9	Reserved	
10	Reserved	
11	Unassigned	
12	SCF	Secondary Receive Signal Detector: Same as pin 8, but not used with most common modems.
13	SCB	Secondary Clear to Send: Same as pin 5, but not used with most common modems.
14	SBA	Secondary Transmit Data: Same as pin 2, but not used with most common modems.
15	DB	Transmit Signal Clock: Used for timing signals between the modem and the terminal.
16	SBB	Secondary Receive Data: Same as pin 3, but not used with most common modems.
17	DD	Receiver Clock: Used for timing signals between the modem and the terminal.
18	Unassigned	
19	SCA	Secondary Request To Send: Same as pin 4, but not used with most common modems.
20	CD	Data Terminal Ready: Used by the terminal to indicate that it is on and ready to send or receive.
21	CG	Signal Quality Detector: The modem asserts this line when the received signal meets specified criteria for quality (strength, frequency, lack of noise, etc.).
22	CE	Ring Indicator: This line is asserted when the modem detects ringing voltage pulses on the telephone line.
23	CH(CI)	Data Signal Rate Selector: Used by the Terminal and/or the modem to select a baud rate and inform the other equipment of that rate.
24	DA	Transmitter Signal Element Timing: Similar to pin 15, but used when the timing comes from a source other than the main modem.
25	Unassigned	

*Asserts is a term meaning "makes active." A line can be asserted by placing a + or − voltage on it, or by pulling it from some voltage to zero, depending on the type of logic convention in use.

necessary to provide data transfer and handshaking, and the amount of current the circuit can carry. In a circuit that meets these criteria, you can short any of the wires together and nothing will blow out or burn up — an important safety consideration. **Table 1** shows these signal names and values; **figure 3** shows a DB-25 connector with the signals and pins identified. It's important to note that not all manufacturers (and designers) have followed these standards to the letter. You may find some equipment that uses certain lines for purposes not covered in the standards, or that omits some signals or lines. The majority of computers and interfaces do, however, follow the standard well enough that most RS-232C devices will work with them.

Why is this important? Many TNCs available today use a cable (called an RS-232 cable) to connect between the computer and the TNC. If you have to troubleshoot the system, and suspect the cable, it's good to know what to look for. There are "breakout" boxes available that can be placed in series with cables such as these to see what's happening. They have several light-emitting diodes (LEDs) that are on or off, indicating the states of the circuits they are monitoring.

Some TNCs are designed to fit into a vacant slot in an IBM PC or compatible. These need no cable — they work from the interface bus in the computer. Their only connection to the outside world is to the microphone, PTT, and receiver audio in your transceiver.

In summary, a modem is an interface between a computer or terminal and either the radio world or telephone systems. It provides both outgoing and incoming translations to make data communications compatible with voice-type circuits. In addition, the packet-radio modem contains software that covers many operating procedures that Amateurs need for successful communications via

packet, ASCII, RTTY, or AMTOR over hf or VHF radio.

If you'd like to read more on this subject, try:

*Get***CONNECTED to Packet Radio*, by Jim Grubbs, K9EI. (An introduction to packet radio for the *newcomer*. Tells how and why, names some equipment and how to use it.)

Understanding Data Communications, by the Texas Instruments Learning Center and available from Radio Shack stores as part number 62-1839. (An excellent book on many phases of data communications. Technical enough for the experienced Amateur, but not so deep as to be impossible for the beginner.)

PACKET

YOUR GATEWAY TO PACKET RADIO
by Stan Horzepa, WA1LOU

Here is the complete beginner's guide to Packet Radio written by ARRL Packet expert, WA1LOU. Beginners will find the complete easy-to-understand explanations eliminate many of the frustrating aspects of packet operation. Full of helpful hints and tips that come from thousands of hours of on-the-air experience. Keep from re-inventing the wheel — learn from an expert. 208 pages © 1987.

☐AR-PKT Softbound $9.95

GET***CONNECTED TO PACKET RADIO
by Jim Grubbs K9EI

This is your Packet Radio Handbook! Over 17 chapters cover every aspect of packet operation from: choosing a packet controller (TNC), an explanation of packet protocol, packet accessories and a primer on how to make your first packet contact to how packet bulletin boards (BBS) operate, plus more! Also has complete appendix with more information on: definitions, bibliography, frequencies, organizations, GLB/TAPR cross reference guide. Xerox 820 info, other publications, suppliers and WORLI commands. Written in an easy-to-read, informal manner, this handbook is must reading for all packet users. ©1986 208 pages — 1st edition.

☐JG-PR Softbound $12.95

ARRL COMPUTER NETWORKING CONFERENCES 1-4
Pioneer Papers on Packet Radio 1981-1985

These collections of Packet Radio papers should be in every Packet enthusiasts shack! Written during the formulative years of Packet development, these papers (too numerous to mention them all) cover: theory, practical applications, protocols, software and hardware subjects. You also get a complete up-to-date collection of all published "Gateway", the ARRL Packet Radio newsletter. As big as the ARRL HANDBOOK. © 1985 over 1000 pages.

☐AR-CNC Softbound $17.95

5th COMPUTER NETWORKING CONFERENCE PAPERS ©1986

☐AR-CNC5 Softbound $9.95

6th ARRL COMPUTER NETWORKING CONFERENCE August 1987

Collection of papers given in August 1987 at Redondo Beach.

☐AR-CNC6 Softbound $9.95

THE PACKET RADIO HANDBOOK
by Jonathan Mayo, KR3T

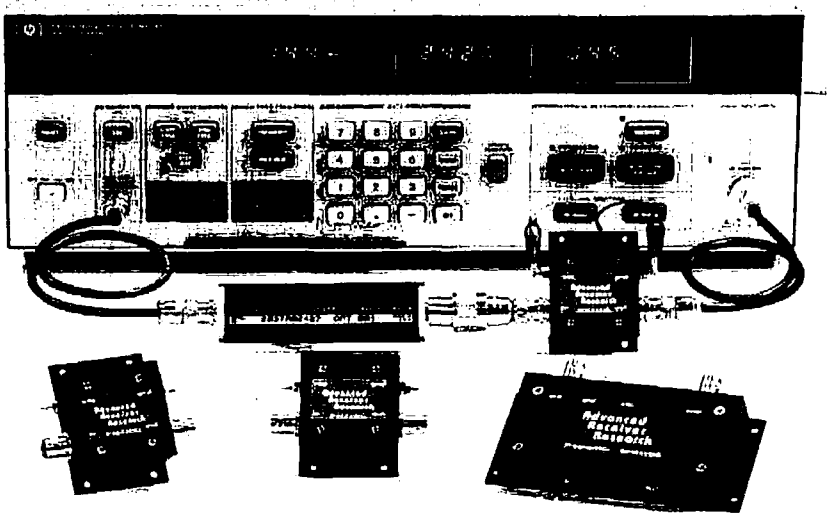
Packet radio combines the power of today's microcomputer with worldwide digital communications. Newcomers will find this book to be full of helpful tips, tricks and information that will help get them on Packet as quickly as possible. Providing you first with packet basics, this book progresses through the inner workings and operational aspects of packet to a look at future technology still in developmental stages. Also includes: using bulletin boards, traffic handling on packet, modulation methods and networking principles, protocols (both AX.25 and VADCG) and a thorough discussion of the various TNCs and accessories available. © 1987 1st Edition 218 pages.

☐T-2722 Softbound $14.95

Please enclose $3.50 shipping and handling.

HAM RADIO'S BOOKSTORE
GREENVILLE, NH 03048
(603) 878-1441

Performance VHF/UHF preamps



Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	$29.95
P50VD	50-54	<1.3	15	0	DGFET	$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	$79.95
P144VD	144-148	<1.5	15	0	DGFET	$29.95
P144VDA	144-148	<1.0	15	0	DGFET	$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	$79.95
P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	18	+12	GaAsFET	$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	$59.95
SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$82.95
SP432VDA	420-450	<1.2	17	−20	Bipolar	$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

Every preamplifier is precision aligned on ARR's Hewlett Packard HP8970A/HP348A state-of-the-art noise figure meter. RX only preamplifiers are for receive applications only. Inline preamplifiers are rf switched (for use with transceivers) and handle 25 watts transmitter power. Mount inline preamplifiers between transceiver and power amplifier for high power applications. Other amateur, commercial and special preamplifiers available in the 1-1000 MHz range. Please include $2 shipping in U.S. and Canada. Connecticut residents add 7-½% sales tax. C.O.D. orders add $2. Air mail to foreign countries add 10%. Order your ARR Rx only or inline preamplifier today and start hearing like never before!

Advanced Receiver Research

Box 1242 • Burlington, CT 06013 • 203 582-9409

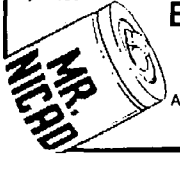
189

BATTERIES

Nickel-Cadmium, Alkaline, Lithium, Etc.
INDUSTRIAL QUALITY

YOU NEED BATTERIES?
WE'VE GOT BATTERIES!
CALL US FOR FREE CATALOG

190



E.H.YOST & CO.
EVERETT H. YOST KB9X1
7344 TETIVA RD.
SAUK CITY, WI 53583
ASK FOR FREE CATALOG
(608) 643-3194

THE 4SQTRON
COMPACT ANTENNAS FROM 160-10 METERS

NO TUNERS!
NO RADIALS!
NO RESISTORS!
NO COMPROMISE!
THREE EXCELLENT REVIEWS JUST DON'T HAPPEN BY CHANCE.
CALL US FOR A FREE CATALOGUE.

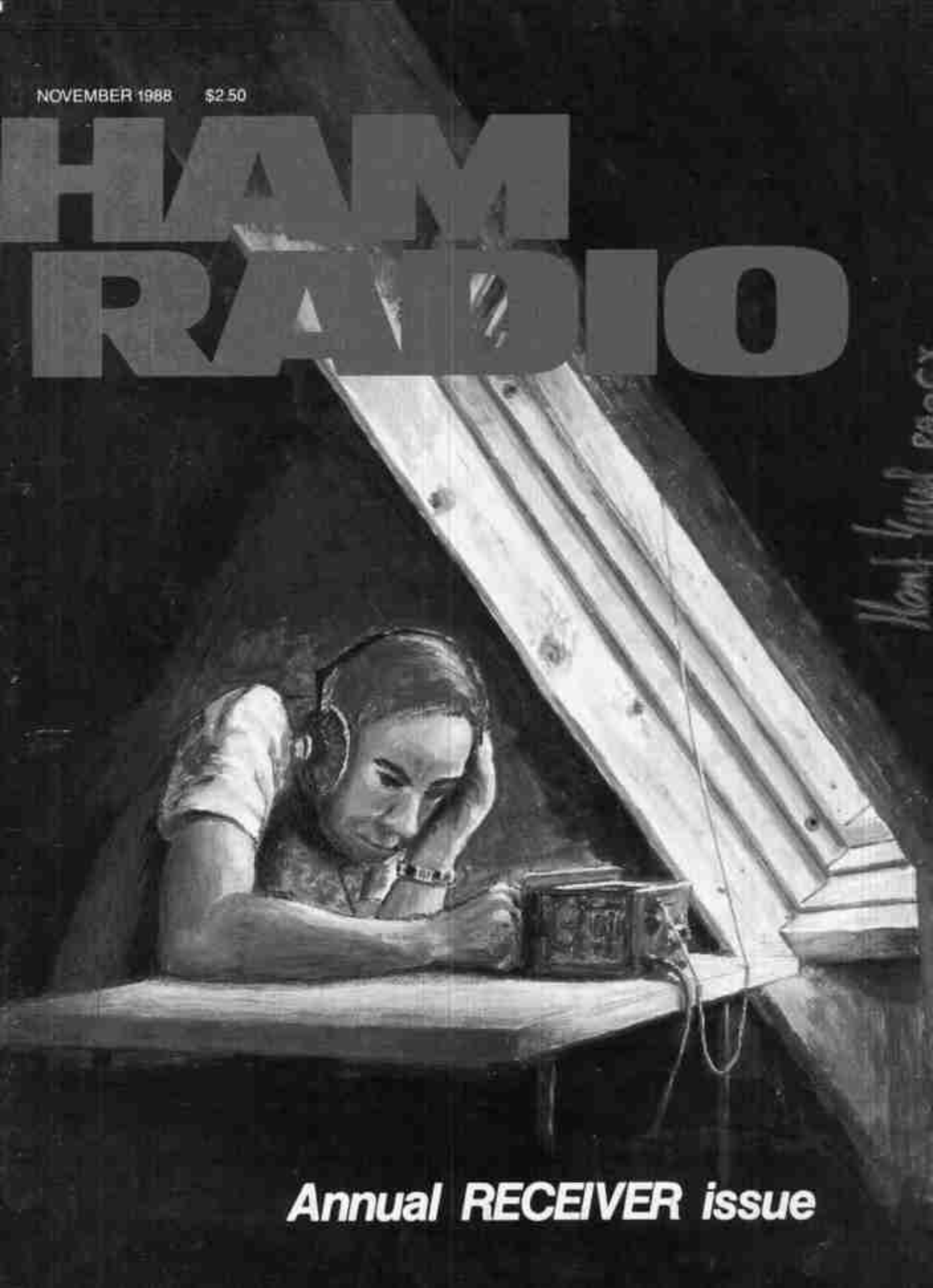
*See review in Oct 73, 1984
*Sept 74, 1985 *March 73, 1986

NEW LOCATION!
BILAL COMPANY
137 Manchester Dr.
Florissant, Colo. 80816
(719) 687-0650

191

NOVEMBER 1988 $2.50

HAM RADIO



Annual RECEIVER issue

HAM RADIO

NOVEMBER 1988

volume 21, number 11

T. H. Tenney, Jr., W1NLB
publisher
and editor-in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
production editor

Peggy Tenney, KA1QDG
copy editor

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Henry S. Gallup, KA1RYG
advertising sales manager

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Phil Alix, N1FPX
traffic manager

Meribeth Buchanan
HAM RADIO Bookstore

Hans Evers, PA0CX
cover

HAM RADIO Magazine is published monthly by Communications Technology, Inc. Greenville, New Hampshire 03048-0498 Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail), one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 125

Microfilm copies are available from Buckmaster Publishing Mineral, Virginia 23117

Cassette tapes of selected articles from *HAM RADIO* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1988 by Communications Technology, Inc. Title registered at U.S. Patent Office

Second-class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *HAM RADIO* Greenville, New Hampshire 03048-0498

FEATURES

10 **Simple Receivers from Complex ICs**
Bill Parrott, W6VEH

24 **The Weekender: Improving Operation with the MFJ 989 Transmatch**
L.B. Cebik, W4RNL



KF7M, page 67

26 **Ham Radio Techniques: The radio boys in the Pacific, or, working DX for Uncle Sam**
Bill Orr, W6SAI

33 **The Pepperdyne Receiver**
Jim Pepper, W6QIF



THE WEEKENDER

W4RNL, page 24
WA9HUV, page 60

60 **The Weekender: A 1296-MHz Low Noise Amplifier**
Norman J. Foot, WA9HUV

67 **A Solid-State 75A-4 Receiver**
James M. Larson, KF7M

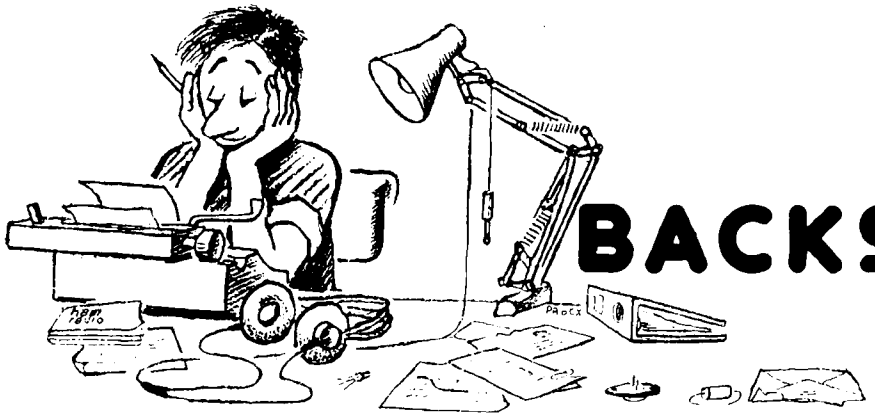
See page 97 for the winners of September's handheld radio contest.

100 **Practically Speaking: An Overview of Operational Amplifiers: Part 1**
Joe Carr, K4IPV

117 **Elmer's Notebook: SSB Basics: Generating the Signal**
Tom McMullen, W1SL

DEPARTMENTS

Backscatter	4	Flea Market	112
Comments	9	New Products	120
Ham Notebook	98	Advertiser's Index	126
Ham Mart	106	Reader Service	126
DX Forecaster	108		



BACKSCATTER

A potential danger...

Recently a great amount of attention has been given to the effects of electromagnetic radiation on the human body. Dr Samuel Milham of the Washington State Department of Social and Health Services (as well as several others*) has written a number of studies indicating that there may be a link between electromagnetic radiation and several forms of cancer. Lately Milham's studies have been picked up by the wire services and articles have appeared in newspapers nationwide. While this isn't a revelation (we all know that at certain frequencies electromagnetic energy can be harmful) it is cause for concern, because one of Milham's study groups consisted of male Radio Amateurs in the States of Washington and California.

In a paper published in the *American Journal of Epidemiology* (Vol. 127, No. 1, January, 1988), Milham observed there was an elevated rate of mortality from several different forms of cancer in male Radio Amateurs in Washington and California, during the years 1979 through 1984.

Looking at the broader field of danger from all forms of electromagnetic radiation, Milham published a paper in *Environmental Health Perspectives* (Vol. 22, pages 297-300, 1985) which included an occupational mortality analysis of 486,000 adult male death records filed in Washington State from 1952 to 1982. He looked at electrical and electronic technicians, radio and telegraph operators, radio and TV repairmen, telephone and power company linemen, power station operators, welders, aluminum reduction workers, motion picture projectionists, and electricians. He states that: "In the 1952 to 1982 data set, men whose occupations were associated with electric or magnetic fields had more deaths due to leukemia than would be expected."

Now before anyone jumps to an erroneous conclusion, let me add that at the end of the first paper, Milham states that the overall mortality for Radio Amateurs compares quite favorably with that of the rest of the population. It's also important to note that these studies are very preliminary and will require additional years of exhaustive work before any firm conclusion can be reached.

One of the biggest dangers with reports like Milham's is that the casual reader may be misled by media reports on the subject written without all the facts. Everyone knows of stories that have appeared on TV or in print, giving only partial information, which have created a great degree of unwarranted concern. Paul Brodeur's 1977 book *The Zapping of America*, while informing us of a potential danger, was written in this kind of sensational vein. Credibility is what's required — not sensationalism!

A number of hams around the world are very concerned about the bio-effects of electromagnetic radiation. In response to earlier concerns, the ARRL has formed a bio-effects committee a number of years ago. Wayne Overbeck, Ph.D., N6NB, and Stu Cowan, W2LX, are also concerned and are cooperating with a number of other concerned amateurs and organizations** in an in-depth study. While neither Overbeck or Cowan are physicians, both are experienced amateurs and want to get to the truth of the matter. Dave Rodman, M.D., KN2M, a medical doctor who is researching the bio-effects of electromagnetic radiation — specifically 60-Hz radiation.

At the ARRL National in Portland, Oregon on September 10th, 1988, Overbeck presented his preliminary findings to a packed audience of interested Amateurs. He summarized the dangers as follows: radio frequency energy, 60-hertz electromagnetic fields, and chemical agents. (See HR's December 1983 issue on the dangers of PCBs.) Overbeck did add some caveats to his research. First, it's difficult to prove cause and effect due to the myriad hazards that we face, both in the workplace and home. Secondly, with cancer, the long latent periods and subtle signs and symptoms often don't become apparent until long after exposure.

Overbeck then presented his audience with a list of common sense precautions: don't run high power into a low directional antenna or more than 25 watts on VHF/UHF mobile installations without first measuring the RF power densities;*** make sure that no one is near a ground-mounted antenna or mobile antenna when it is transmitting; and make sure that all power amplifiers are fully shielded when in use. Overbeck

(continued on page 114)



COMMENTS

Priceless covers

Dear HR:

My wife Ginger, N5LTH, and I look forward to the *HAM RADIO* covers! PAØCX really understands the hobby and seems to always come up with a clever idea or humorous slant. He is great at using body language to tell a story. Your July "cover story" for instance is familiar to anyone who has built something from scratch—the ham is proud of his fantastic VHF circuit (his nose says so) but he's worried that people will laugh because he's used an old teapot as his resonant cavity! (crossed arms, knees together). The September cover, also cracked us up; the guy is pretending to be asleep, hoping that someone will try to make off with his treasures (note the unmistakable BC-348 and 811A) so that he can press the foot switch and zap them with the old spark coil. (See the half open eyelids and the little wires connecting all the goodies?) This is priceless. Your covers completely outclass those of any other ham magazine.

Since you are soliciting feedback on the technical and construction format — please keep up the technical emphasis. *HAM RADIO* and *QST* are the only "technical" magazines left. Please keep it up — we need you!

Don Murray, W9VE,
Dallas, Texas 75218

Congratulations!

Dear HR:

The all new *HAM RADIO* is superb. Your editorial staff has achieved a remarkably well-balanced publication—one that should appeal to just about every segment of the Amateur Radio community.

The universe of Amateur Radio presents a major challenge to those engaged in producing a technically, applications-oriented magazine. Clearly you have found the formula to yield a useful and meaningful contribution to those of us who enjoy not only operating our equipment, but also for those who still enjoy the thrill of experimentation and "rolling our own" equipment.

Your new graphics are excellent and so professionally tied in with the main theme of the story. The return of the reader service card is welcomed. It is efficient and effective...though it appears limiting the number of inquiries to 15 may dismay some of your advertisers. I usually seem to find a desire to exceed the limit.

I have every issue of *HAM RADIO* in binders, so I find your mailing wrapper a nice touch in eliminating the damage previously inflicted upon your great magazine by the postal service.

Your shorter stories are refreshing, but do run the occasional longer, in-depth story when the subject matter warrants the treatment.

In summary, the *HAM RADIO* staff deserves a round of prolonged applause for your response to your readers needs and in producing one of the finest Amateur Radio magazines available anywhere on our globe.

Kenneth M. Miller, K6IR,
President,
National Capitol DX Association,
Rockville, Maryland 20853-1128

Big is better

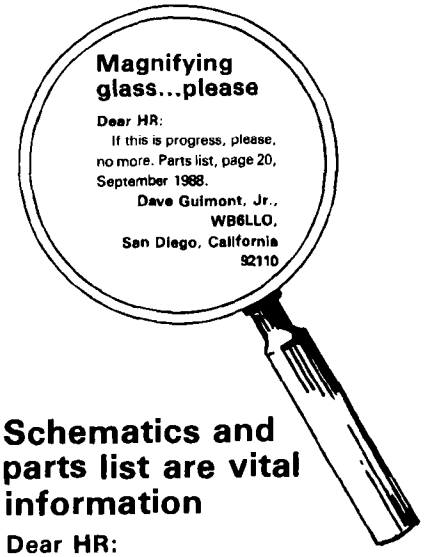
Dear HR:

I have been a subscriber of *HAM RADIO* for many years and my subscription, I believe, runs until 1991. However, the new format, in my opinion, is "lousy"!!! I would much rather have the usual "BIG" technical (articles) with depth than the smaller ones as depicted in the September, 1988 issue.

The interspersing of advertising with editorials turns what was once an excellent technical publication into a *QST* (which is okay for what it is supposed to achieve) or a *CQ*.

Perry Pollins,
Lexington, Massachusetts
02173-0362

Our advertising has always been mixed with our editorial content. Ed.



Schematics and parts list are vital information

Dear HR:

I just received my September 1988 issue of *HAM RADIO* and would like to congratulate you on the new format, with one exception. I was disappointed in the article entitled, "A Direct Synthesis VFO," by Robert J. Zavrel, W7SX. Don't get me wrong, I found the article very informative and well written. However, there were no schematics or parts lists accompanying it.

I have always enjoyed reading *HAM RADIO* for its technical content and construction articles but, I viewed this article more as an advertisement than

(continued on page 104)

SIMPLE RECEIVERS FROM COMPLEX ICs

By Bill Parrott, W6VEH, 7662 Bellaire Avenue, N. Hollywood, California 91605

As integrated circuits become more complex, ham designs can become correspondingly simpler and smaller. Multifunction ICs open the door to a whole new world of simple "weekender" receivers for Novices and old-timers alike.

Who needs a simple receiver?

Simple receivers, like the ones I'll describe, are good ones for beginners. They help bridge the "if you want to be a ham, you have to make a major investment" gap. But simple receivers shouldn't just be dismissed as Novice devices. They can be used in homebrew test equipment, time standards, net monitors, panadaptors, and other gadgets where the main shack receiver isn't appropriate.

Design goals

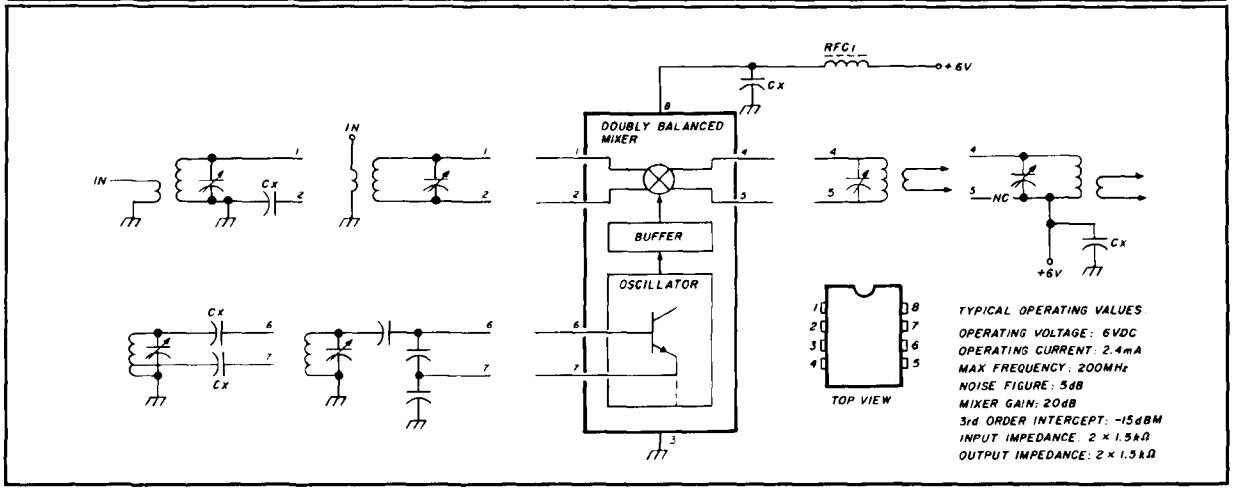
My projects started with a need to test some mobile antennas. I built a noise bridge, using the circuit in the *ARRL Handbook*, but it needed a receiver as a noise detector. Dragging a large expensive receiver out into the driveway was clumsy, so I decided to build my own.

What I needed was a simple, low-power receiver that was quick and easy to build. I considered several of the "one-IC" receiver designs, but decided that while the chips were simple, the layout and debug problems were not. I settled on the good old direct conversion (DC) approach. Then I discovered the Signetics NE602N, one of those "magic" chips that unlocked both of the following designs.

A magic mixer

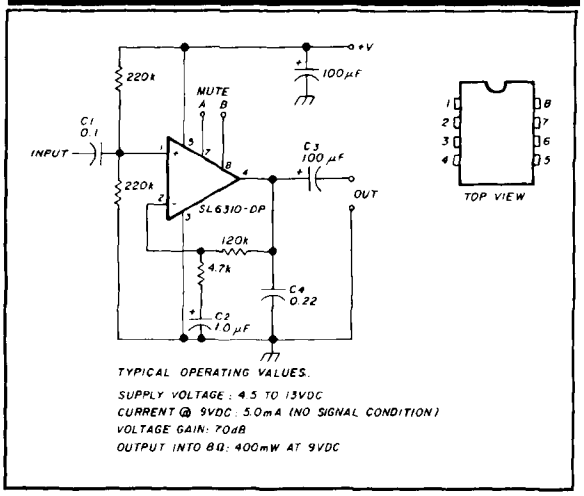
The NE602N shown in **fig. 1** is a combination chip, consisting of a double-balanced mixer and an internally connected bipolar oscillator with built-in buffering. The mixer portion is similar to the MC1496G, except that the eight external resistors usually required with the MC1496 have been moved on-chip. The oscillator is also internally

FIGURE 1



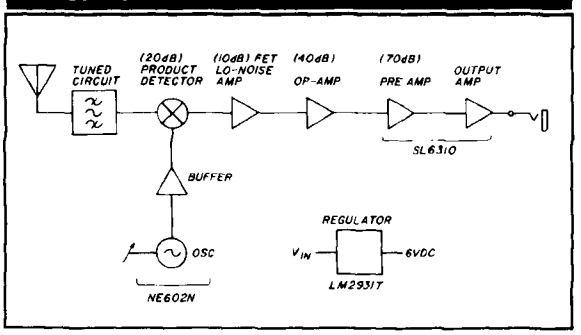
One of the possible configurations of the NE602N. Balanced circuits are preferred, but may be difficult to implement.
Cx: Blocking/bypass capacitors, 0.001 to 0.1 μF, depending on operating frequency.
RFC 1: Ferrite beads or RFC, recommended at higher frequencies.
Unmarked components are tuned circuit elements.

FIGURE 2



Plessey SL6310-DP high-gain audio amplifier. All capacitor values are µF. The values shown are for "hi-fi" operation. The low frequency response can be raised by decreasing C1, C2, and C3. The high frequency response can be decreased by increasing C4. The mute pins are internally biased, and may be left open. Grounding "A" or connecting "B" to pin 5 will mute the output. The mute connections must include a 100k series resistor.

FIGURE 3



Block diagram of the 3 × 8 direct conversion receiver. Having more than one function per chip is advantageous.

biased, with the cathode and base connections brought out. The circuits shown in **fig. 1** are examples of some of the ways to use the chip; many other versions are possible. If you compare these circuits with the usual front-end designs and then review the performance specifications, you'll see why it can be a magic chip for very simple low-power receivers!

A word of caution is in order: the internal biasing of the NE602N requires that the external circuits be isolated from ground and power, or that blocking capacitors be used. The mixer outputs are an exception; they can be connected to the positive source voltage through the output circuit.

Signetics has published only a preliminary data sheet[1], and their application note[2] adds very little information. However, the information included here is really all you need. The chip is very easy to hook up and the oscillator seems to work with almost any breadboard lash-up.

A magic audio amplifier

I was encouraged by finding the NE602N and started looking for a good audio amplifier to go with it. Most DC receivers use a chain of high-gain audio stages followed by some compromise design for the output stage. After a lot of searching, I finally discovered the Plessey SL6310C, another magic chip — at least for this design.

The SL6310C (see fig. 2) can be described as a *noninverting* op amp, with an 8-ohm power output. In one eight-pin package I had a high-gain preamp, and more than enough audio output. The device can be muted, using pin 7 (active low) or pin 8 (active high), but these pins may be left open if you don't need the mute function. With 70 dB of gain and 400 mW of audio output, it's a great device.

A magic regulator

Because the NE602N is optimized for 6-volt operation, and since I wanted to use a 9-volt (2U6) transistor radio battery, some kind of voltage dropping and regulation was required. Zener diodes are fine for some applications, but proper operation requires that they draw heavy (10mA) current. Most of the common integrated regulators also consume a fair amount of current. My third magic chip was the National LM2931, an adjustable voltage regulator. Its quiescent current is only 400 µA, and its "headroom," or input/output differential, is only 0.6 volts! It's an "automotive" regulator and is self-protecting against shorts, overloads, reversed input voltages, and 60-volt transients. It was an ideal part for the purpose.

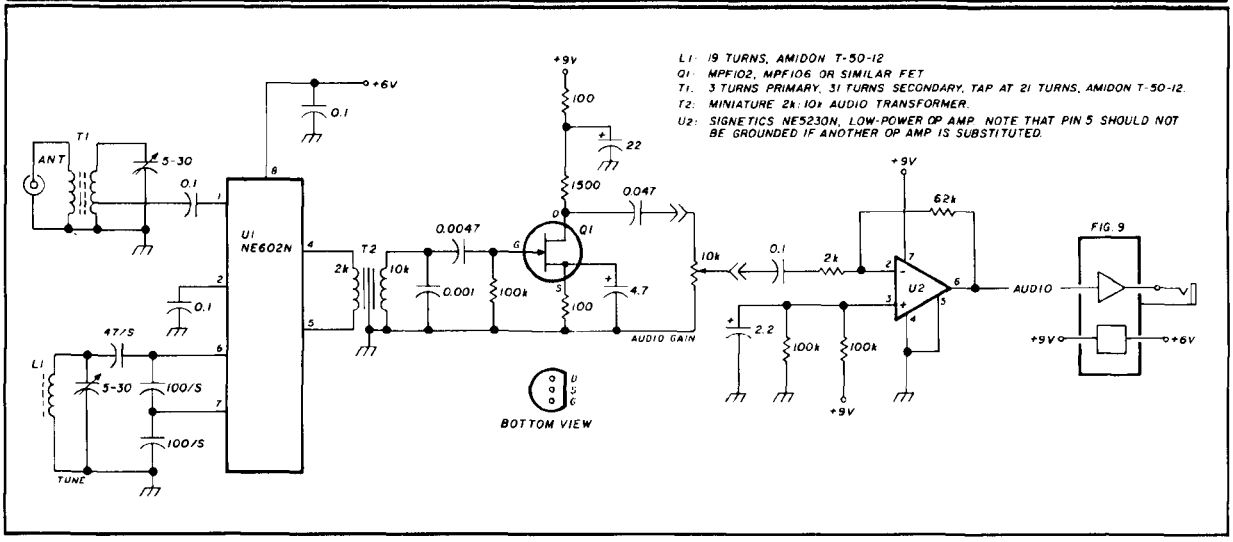
The 3 × 8 + 2 design

Armed with these chips, I started my noise-bridge detector design. The shortcomings of DC receivers, like microphonics and poor selectivity, are well known. However, the shortcomings had to be balanced against the advantages of small size, low current, and freedom from image problems.

Images would be a major problem with a superhet. There would be a high noise level at the image frequency, and with simple input circuits, the desired null might be masked by the image noise. Here's one of those rare occasions where a DC receiver could outperform a superhet.

I tried to keep the number of components to a minimum, but with only 20 dB of mixer gain and 70 dB of audio, the results were marginal. I added an op amp to pick up the needed gain, but I found that other authors were correct when they put a low-noise FET amplifier in front of the audio chain. Without it you have S9 + 40 op amp noise. I could have used a low-noise op amp

FIGURE 4



Schematic of the 3 × 8 direct conversion receiver. The tuned circuit values shown are lor the 10-meter version, but they are easily scaled for other frequencies. Whole numbered capacitor values are pF, except for polarized capacitors which are μF. Decimal capacitors are also μF. Components marked /s (stable) are polystryane, silver mica, or NPO ceramic. The audio and regulator circuits are "recycled" from *fig. 9*.

instead, but the good low-noise ones draw about 14 mA. This would have exceeded my power budget.

The final DC receiver design is shown in **figs. 3** and **4**. The block diagram is expanded to show the many functions available from the few chips.

The front-end circuits are "no frills". The mixer shows the usual tuned circuit input, but for noise bridge use I detuned this circuit. Signals in the CB, 10 meter, and commercial ranges made the null hard to find. For noise bridge applications you can leave the capacitor out; you'll need the usual tuned circuit for other applications.

The oscillator is a simple Colpitts, which inherently provides the necessary isolation for the base and emitter input pins. For my application, bandspread tuning wasn't needed. With the components shown, the oscillator tuned from about 26 to 32 MHz. Note that this simple tuning arrangement is adequate for some test equipment, but not for communications reception. Tuning in an SSB signal on this receiver required the "freeze and hold your breath" technique. Better circuits are shown for the 5 × 8 design below, and can be substituted here.

To provide a load for the mixer output, I used one of the common 10k:2k (Radio Shack) audio transformers, with primary and secondary reversed. Terminating the secondary in a 10k resistor reflects a reasonable load back into the mixer. The transformer frame must be grounded, because its stray capacitance helps to keep RF out of the audio circuits.

The FET amplifier is straightforward; you can substitute almost any other type of low-noise FET for the one specified. The op amp circuit is also straight from the books. Note, however, that the op amp is one of the new low-current (1 mA) types, which helps to keep the overall current drain to a minimum.

The SL6310C (See **fig. 9**; both designs use the same audio and regulator circuits.) provides the remaining audio gain, and also supplies the power needed to drive earphones or a speaker. Most simple receivers have weak audio outputs, but not this one. If your results duplicate mine, you'll seldom turn the audio gain all the way up!

For simplicity you would use a 6-volt battery and eliminate the voltage regulator, but the oscillator would be unregulated and the frequency would drift slowly as the battery voltage dropped. I included the regulator in my design so I could use a 9-volt transistor radio battery.

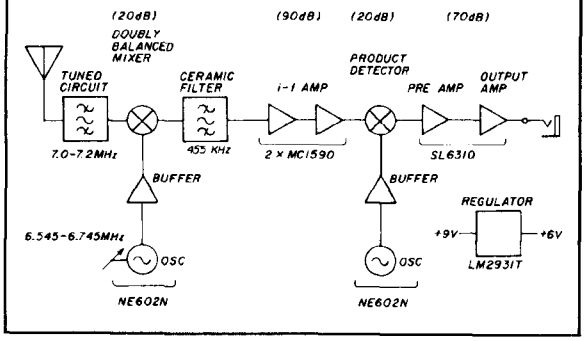
Construction

Sorry, no circuit board layout. I built the receiver on some computer prototype circuit board scraps.

You can use almost any of the usual assembly techniques. There are only a few special precautions to observe, provided you follow the usual ones like keeping the outputs well away from the inputs. One precaution concerns the audio output power circuit. Be sure to use heavy leads and run them directly back to the battery; this circuit can pull heavy current on audio peaks. Also, the 100-μF filter capacitor should be mounted very close to pin 8 because its purpose is to supply these peak currents.

The other precaution is to build the oscillator "like a battleship," since the high audio gain makes the receiver microphonic. This effect is characteristic of DC receivers in general. Careful attention to mechanical details is

FIGURE 5



Block diagram of the 5 × 8 40-meter superhet receiver. There are ten functional stages in five 8-pin ICs.

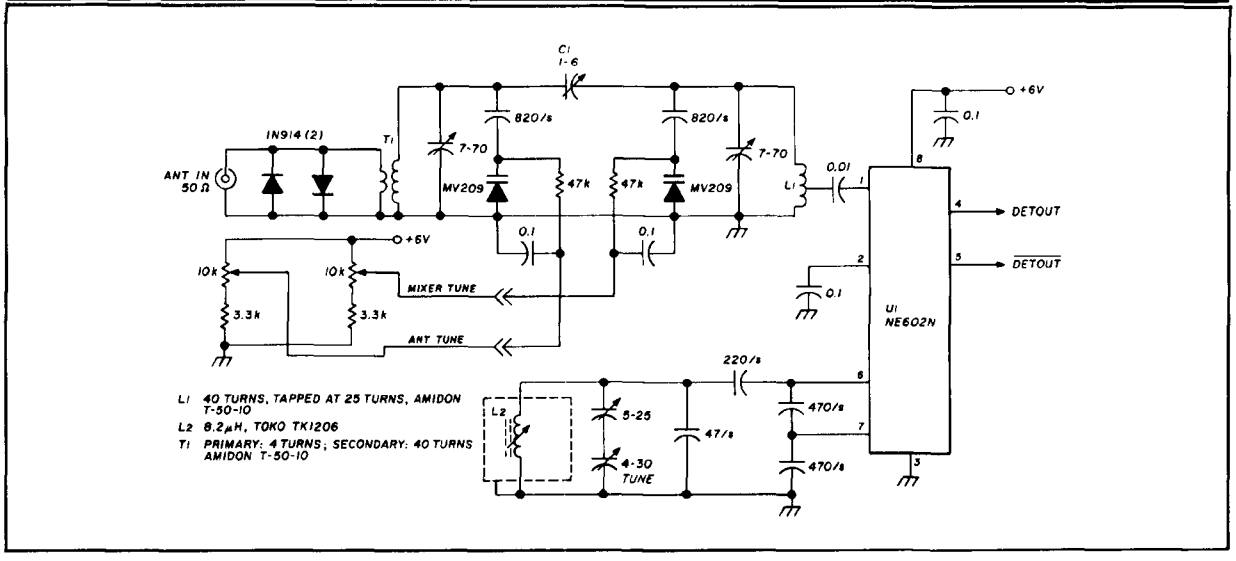
well into the VHF range, you can use this receiver anywhere between 20 kHz and 200 MHz by changing the mixer and oscillator components.

The 5 × 8 + 1 design

OK, so I got hooked. If my DC receiver was that easy to build, a simple superhet should take only a few more parts. About this time, I found a low-cost source for Toko i-f transformers and slug-tuned coils. That did it. With the above chips, and low-cost RF and i-f coils, the superhet receiver almost designed itself.

In this second design, I kept most of the previous design goals: small size, simplicity, low cost, and low current drain. I decided to switch to 9 volts of AA-size batteries, since the life of the 2U6s would be too short.

FIGURE 6



Mixer/first oscillator circuits for the 5 × 8 receiver. Decimal capacitor values of μF; whole capacitor values are in pF. Capacitors marked /s are polystryene, silver mica, or NPO ceramic. Values are for 40 meters.

necessary to keep the receiver from living up to its name as a "boing box."

There's little to debug other than wiring errors or defective components. The only adjustment is to the local oscillator. Tweak the coil and capacitor until the proper tuning range is obtained.

Performance

I've built several DC receivers, and this design seems much less microphonic than the others — probably due to the 20-dB mixer gain. With a 5-dB noise figure and 400 mW of audio it is a "hot performer." Selectivity is typical; stability depends on the oscillator circuit and oscillator components used.

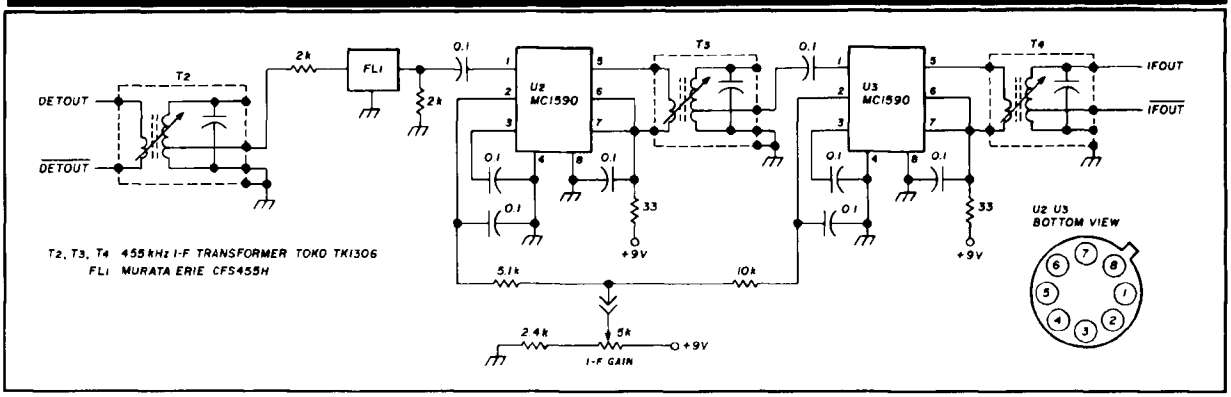
The version shown, a broad-tuning 10-meter receiver, is of limited use. However since the NE602N will work

The goals that I chose imposed some performance limitations, and I had to leave out some of the usual extras, like AGC and audio filtering. However, the basic circuits are easy to modify and the design can be expanded to meet other objectives and purposes.

The block diagram of the 5 × 8 is shown in **fig. 5**. An eight-pin mixer/oscillator buffer, two eight-pin i-f stages, an eight-pin product detector/L.O. buffer, and an eight-pin audio amp/output stage, plus an IC regulator make up the whole design. While the schematic looks complicated, try comparing it to other designs with the functions listed above and you'll see the difference!

If you add up the stage gains, the result seems like overkill — and it would be, except for the insertion losses in the interstage networks. I didn't include the losses in the block diagram because I couldn't measure them

FIGURE 7



5×8 i-f amplifier.

accurately. Better impedance matching would cut these losses and improve the gain, but it's an unnecessary step since there's gain to spare.

The front-end circuits

The front end (fig. 6) is an expansion of the circuit used in the 3 × 8 design. The mixer is double tuned to reduce images. Varactor tuning is an added frill that's handy but not really necessary. If you plan to use the receiver with one antenna, and on one part of the band, you can use trimmer capacitors. Peak them once and forget them. If you want optimum performance with random antennas, use either panel-mount capacitors, or varactors as I did. The controls serve a dual purpose; you can peak them for best DX reception, or use them as attenuators when the guy down the street fires up his kW rig.

The oscillator is a standard Colpitts with components added to provide the required bandspread. The component values I used are shown in the diagram. You should expect some cut-and-try adjustments; component tolerances make the values given simply approximations.

Using a Toko slug-tuned coil for L2, instead of the usual solenoid or toroid coil, was a gamble that paid off. I was concerned with possible drift problems, but the results (at least in my case) were excellent. Having a slug-tuned coil in the oscillator makes alignment a quick, simple task. My guess is that while this little slug-tuned coil is electrically inferior to a toroid or solenoid, its thermal performance is superior due to its small size, shielding, and bonding to the circuit board.

Many authors report glowing success with their particular oscillator designs, but unless several identical units have been built with consistant results, you can suspect that the author may have been lucky. When you build a new receiver you should be prepared to swap parts and move and bond leads until you get the oscillator performance you want — even if your circuit is an "exact copy" of a published design. A good oscillator is part science, part art, and part luck.

The i-f stage design (fig. 7) is right out of the book. I could have used hotter i-f amplifiers than the MC1590, but, it was the optimum choice based on a gain/mA criterion and my design goals. Some authors use resistance-coupled designs, and rely on the filter to provide all the selectivity. I chose to use transformer coupling instead, because a resistance-coupled amplifier will amplify anything presented to it. With more than 80 dB available, any stray signal that happens to get into the amplifier chain will appear at the detector. Transformer coupling limits the passband to the signals of interest, and reduces the requirements for shielding, filtering, and decoupling.

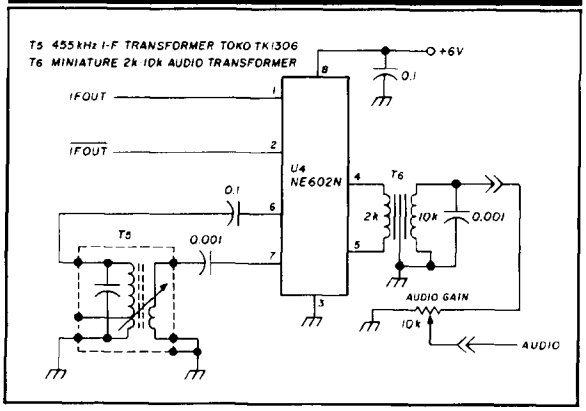
The Toko i-f transformers aren't special parts. I used them because they were inexpensive and easy to obtain. If you have a scrap transistor radio in your junk box which has 455-kHz transformers in it, use your transformers instead of the Toko ones. Because the filter sets the bandwidth, the transformer parameters are not critical.

I used a 6-kHz ceramic filter to set the receiver bandwidth. You might argue successfully that a narrower filter would be a better choice. The filter I used was more of a "procurement opportunity" than a deliberate choice, but the selection turned out to be a good one. Ideally you should use a much narrower filter, but then you'd have to switch the product-detector local-oscillator frequency and the accuracy and stability requirements would increase. The choice, and the resulting complications, depend on your needs and inclinations.

The product detector (fig. 8) also uses the NE602N; the mixer portion is a repeat of the above. For the oscillator-tuned circuit, I used one of the Toko i-f transformers in a Hartley configuration. I assumed correctly that the transformer's built-in tuning capacitor had NPO characteristics and that the frequency drift would be minimal.

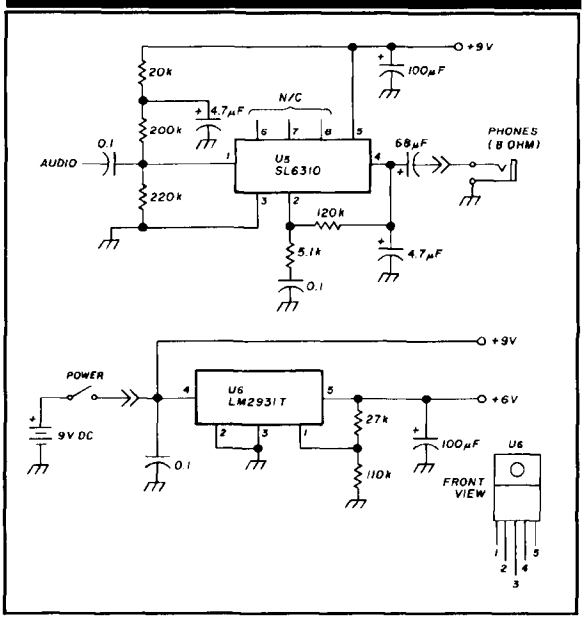
Note that the capacitor at pin 7 is 0.001 μF, while the other blocking capacitors are larger. In the whole design/debug cycle I had only one unexpected problem.

FIGURE 8



5×8 product detector/second oscillator. See text for comments on the capacitor at U4-7. The oscillator could be made tunable by adding a varicap diode across T5, using the circuit of *fig. 4*.

FIGURE 9



Audio and regulator circuits for both the 3×8 and 5×8 designs.

With a larger value capacitor, the circuit acted like a blocking oscillator and put out RF in short bursts. Reducing the capacitor to the value shown cured the problem. It's a point to consider if you use the NE602N in other designs.

The audio amplifier and regulator circuits (**fig. 9**) are identical to those used in the 3X8 design, and the same comments and precautions apply. When using earphones, be sure that you turn the audio gain down before you turn on the power!

Construction

Again, there is no circuit board artwork, because I built the receiver modular fashion. The circuits are ideal for a printed circuit layout; perhaps someone will contribute one. I would recommend building the receiver on two boards, one for the front end and one for the rest, as only the front end needs to be changed to move the receiver to different bands.

One construction problem arose when I mounted the Toko coils and the filter, because their mounting dimensions are metric. I saved a lot of time and frustration by making drill templates on small pieces of brass. The coil dimensions are shown in **fig. 10**. Dimensions for the filter depend on the one you choose — there is no one standard size. The effort required to make the templates is quickly repaid when you drill a circuit board.

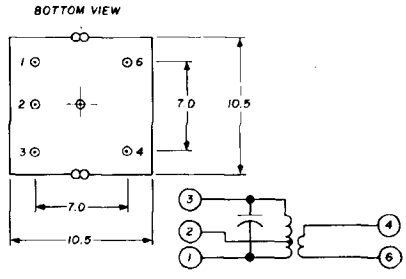
Assembly precautions

The same audio amplifier precautions mentioned above for the 3 × 8 design apply here. It's a good idea to put brass shields across the filter, the MC1590Gs, and between each mixer and its oscillator. These shields aren't shown on the schematics because I'm not certain that they are required. Shielding never hurts, and shields are easier to build in at the beginning than to add later.

If you are new at construction, I strongly recommend that you resist the temptation to crowd everything into a tiny, tightly packed assembly. If you use reasonable spacing, lots of shielding, plenty of decoupling, and keep outputs well away from inputs, your receiver should work the first time.

If you're experienced, you can make the receiver very small. The i-f transformers are available in 7-mm sizes; varactor tuning capacitors can be used; and Motorola has just announced the MC1490G, a flat-pack equivalent of the MC1590G. I suggest you build a larger version first, just to get a feel for the circuits.

FIGURE 10



Mounting dimensions for the Toko transformers. The measurements are in mm. Drill the center hole for a standard-sized screw to hold the template on your circuit board while drilling.

Alignment

The first alignment step is to get the product detector and i-f strip adjusted. If you have a signal or sweep generator that covers 455 kHz, just clip it to the output of the mixer and tune up the transformers and the product detector.

If you don't have the proper equipment, you could steal a signal from the second detector of any battery-operated transistor radio. Don't interconnect the grounds; with one clip lead between radios you can get enough stray signal for a preliminary alignment.

With front-end alignment comes the familiar problem of setting the oscillator on the proper frequency (455 kHz below the input) and getting the required bandspread. You will need a calibrated test oscillator or a general coverage receiver to do this properly. I used an old, but accurate, grid-dip meter. With the oscillator tuning capacitor set to maximum, adjust L1 for the low-frequency setting. Then with the tuning capacitor set to minimum, adjust the series capacitor for the high-frequency setting. The settings interact and several tries will be necessary. You may need to change or pad a capacitor if you can't get the desired range.

Front-end adjustment is simple. Hook an antenna to the rig, find a strong signal, set the varactor controls to middle range, and peak the input capacitors. If you want bandpass tuning, use a sweep generator to set C I to its optimum value. A fair job can be done by setting C1 to minimum, peaking the antenna and mixer adjustments, and then increasing C1 until the output signal just starts to drop.

Once you can tune in signals, you can retouch the i-f transformers for peak performance. Use a weak signal to prevent amplifier overload. Because the filter's characteristics control the passband, you can't miss the proper adjustment points.

Performance

As I pointed out in the beginning, this was a compromise design and some tradeoffs had to be made to meet the design goals. The hardest one to accomplish was getting reasonable performance while keeping the current drain to a minimum.

On the 40-meter band, the input noise figure isn't important because external noise predominates. However, it's nice to know that the mixer does have 5-dB capability. Gain is always important, but that's not a problem here. When the controls are turned all the way up, the audio output limits on antenna noise.

The overall receiver performance is limited by the i-f bandwidth. In the weakest signal case, it is the noise riding through with the signal that limits the sensitivity. A narrower filter would improve this, but as pointed out above, you would then have second-detector oscillator problems to solve.

The receiver was designed for casual use, not for DXCC. However, when the band is open, WAS would be easy. From my area, with a dipole antenna pointing EW and up about 15 feet, the W2s and W4s are S9 + most of the time, and the W5s and W7s are S9 + 40.

Battery drain is about 26 mA. While the design value for the power source is 9 volts, I actually use NiCds (7.2 volts) which work equally well. One evening while trying out the breadboard version, the receiver went mushy and quit soon afterward. I checked the battery pack and found that I had been listening to the receiver until the batteries had dropped to about 3.2 volts! Goal achieved.

Stability, as I've mentioned, depends on several construction factors and adjustments. My "statistical sample of one" sat on W87PAX, the Pan-American Games station, for over two hours, copying SSB without adjustment. This was outside, with no cover on the receiver.

One unsolved problem is the feedthrough of images from strong commercial and SWBC stations that can be S9 + when the band is open. However, since I have seen the same problem in some very expensive commercial receivers, I don't feel that I'm alone. A better front end design could help cut the interference down somewhat, but it would complicate construction.

You'll find the SL6310 a real performer as an output amplifier. With a 4-inch speaker you should have armchair copy 10 feet away. When I use the receiver outside, my XYL keeps reminding me to "Turn that thing down before the neighbors complain!"

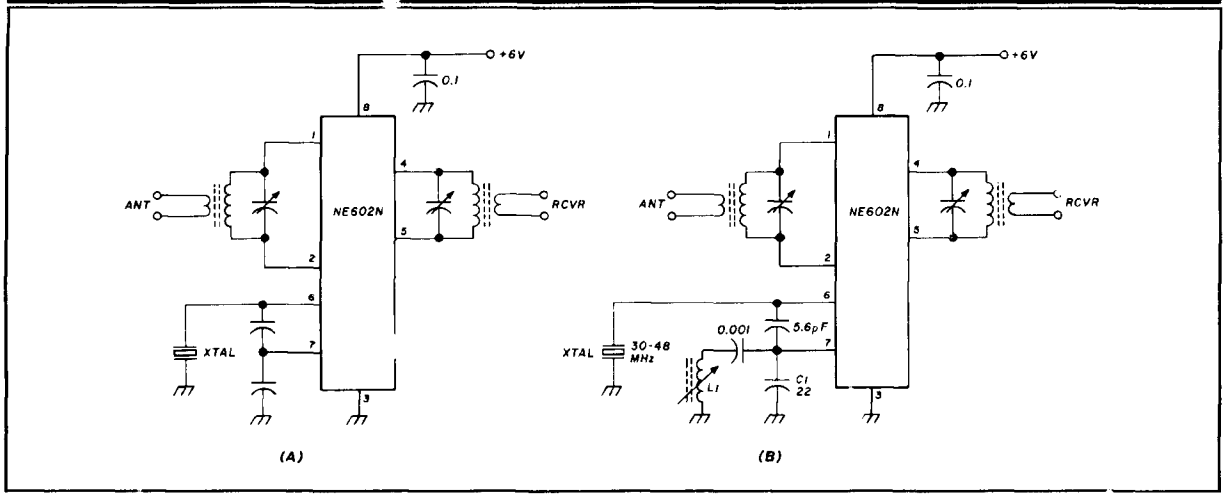
I've tried to provide a detailed description of the receiver performance. If you decide to build the receiver, you'll either be delighted or disappointed, depending on what you expect. If you expect this receiver to outperform its $500 commercial counterpart, you will be disappointed. On the other hand, if you think that a receiver built from five eight-pin chips is just a toy, you could be quite surprised and pleased with the performance.

Room for improvement

Home construction projects are never really finished, but at some point you just have to draw the line. This one is no exception. Here are a few things I didn't do, that could improve the performance of the receiver:

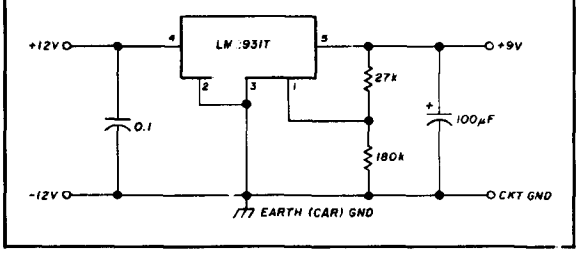
- The filter wants to be terminated in 2,000 ohms. I didn't consider the shunt and series impedances of the source and load when I designed the circuit. The input 2k resistor could be reduced, and the output 2k resistor increased for a better match. The result would be a flatter passband.
- The antenna and mixer tuned circuits were not optimized for impedance match. I did some calculations on the computer and built the circuit accordingly. When winding these coils, you might add a few extra taps and then try to find the optimum tap combinations for best performance.
- The impedance match between the i-f transformers and the mating circuits are undoubtedly incorrect. I tried

FIGURE 11



Simple converters using the NE602N. (A) shows the circuit for fundamental crystals; (B) shows the circuit for overtone crystals. Component values for (A) depend on the frequency being converted. The (B) circuit oscillator is appropriate for 10 meters. L1 and C1 should be rough-tuned to 30 MHz, to assure operation on the proper overtone frequency.

FIGURE 12



A recommended preregulator circuit for use with automotive systems or 12-volt DC wall adapters. Note that a connection to car body or earth ground is shown to reduce stray noise and signal inputs.

to get a data sheet on the transformers, but all Toko had was one of those half-English short-form sheets, with no useful design information on it.

Additions and changes

Rather than load this discussion with detailed footnotes, I'll just point out that "Everything you ever wanted to know..." can be found in the *ARRL Handbook*, in *Solid State Design for the Radio Amateur*, and in the back issues of *HAM RADIO* magazine. You can find circuits for AGC, tuning meters, coil designs for other bands, crystal calibrators, and the other typical options.

For CW operation, the most valuable addition would be a sharp audio filter. If you plan to use an op amp active filter, and are using a battery supply, be sure to check the op amp current requirements; some op amps are real current hogs.

For maximum utility you might want to add a switch at the i-f output and provide diode AM detection and FM detection in addition to the SSB product detector.

Those higher frequencies

Receiver performance will drop off above 10 meters, due to oscillator stability requirements and image problems. The solution is to use a front end converter. Here again the NE602N can be pressed into service. Two such converters are shown in fig. 11: one for fundamental crystal oscillators, and the other for overtone oscillators. Because there is a wide range of inexpensive microprocessor crystals available, and since the converter will draw less than 3 mA, using one of these converters makes it easy to move your receiver anywhere you want — up to the 200-MHz converter limit.

As an example, Digi-Key offers a 23.4-MHz fundamental crystal ($1.62). Using this crystal in the fig. 11

Parts List

Mfr	Part number	6 dB B.W.	50 dB B.W.	S.B. Ar	Term	Case
ME	CFW455H	6 kHz	18 kHz	35	2k	P
ME	CFW455I	4 kHz	15 kHz	35	2k	P
KY	KBF-455R-7A	7 kHz	18 kHz	37	2k	P
KY	KBF-455R-4A	4 kHz	15 kHz	37	2k	P
NTK	LF-H6	6 kHz	18 kHz	40	2k	P
NTK	LF-H4	4 kHz	15 kHz	40	2k	P
NTK	LF-C4	4 kHz	12 kHz	40	2k	M
NTK	LF-C6	6 kHz	16 kHz	45	1.5k	M
ME	CFM455H	6 kHz	15 kHz	45	2k	M
ME	CFM455I	4 kHz	10 kHz	45	2k	M
NTK	[illegible]54	4 kHz	12 kHz	50	2k	M
NTK	[illegible]E6	6 kHz	16 kHz	55	1.5k	M
ME	CFR455H	6 kHz	15 kHz	55	2k	M
ME	CFR455I	4 kHz	10 kHz	55	2k	M
ME	CFR455J	3 kHz	9 kHz	55	2k	M
ME	CFS455J	3 kHz	9 kHz	60	2k	M
ME	CFS455H	6 kHz	15 kHz	70	2k	M
NTK	LF-D6	6 kHz	15 kHz	70	1.5k	M
ME	CFS455I	4 kHz	10 kHz	70	2k	M
NTK	LF-D4	4 kHz	10 kHz	70	2k	M
ME	CFK455H	6 kHz	15 kHz	80	2k	M
ME	CFK455I	4 kHz	10 kHz	80	2k	M

converter, with the 5 × 8 set around 5.1 MHz, will produce a 10-meter receiver. The exact frequency of the 5 × 8 will depend on the part of the 10-meter band you want to receive.

If you plan to use the receiver only with a converter, you won't need the elaborate double-tuned mixer circuits. A simple single-tuned circuit is adequate. Unfortunately, you'll probably need a double-tuned circuit at the converter's input to reduce images and strong stray signals.

Instead of adding a converter, you can use one of the circuits of **fig. 11** as the mixer/oscillator input stage for fixed-frequency operation. This can be handy for nets or for frequency-standard reception. If you use this approach for WWVH or a similar station, consider using a diode detector in place of the product detector.

Alternate power sources

In addition to operation from dry cells or NiCds, you could run these receivers from many other sources because the current drain is low and the voltage requirements aren't strict. However, there are a few things to consider. If you plan to rob power from some existing supply, be certain the supply voltage is "clean." If the supply also powers digital circuits or a microprocessor, you could have switching noise on the power supply lines. These receivers are hot; even a few microvolts of RF on the supply lines could show up in the receiver. A preregulator helps a lot (see **fig. 12**) to clean up a contaminated supply. If you still have problems, add some RF chokes and filter capacitors as required.

Parts procurement

Unless you are very lucky, you won't find the ICs that I used (see parts list) through surplus channels. They are available through the usual distributor channels, but most distributors have a $20-$30 minimum charge. Many ham clubs have a group purchase plan to get around this problem.

The same is true for the ceramic filters. I can't recommend a reliable source, but they are common flea market items. As with crystal filters, the more elements used the better the performance and the higher the price. Because the catalogs for these parts are hard to obtain, I've listed some selected example. The parts list key follows:

ME: Murata Erie
KY: Kyocera
NTK: NTK Technical Ceramics
6 dB B.W.: Filter bandwidth at the 6 dB points
50 dB B.W.: Filter bandwidth at the 50 dB points
S.B. Attn: Stop Band Attenuation, performance of the filter outside its passband.
Term: Input and output termination impedance, ohms.
Case: P = plastic, M = metal

The filters shown are ranked in order of increasing performance. Expect to pay $5 to $25, depending on the characteristics. The first few on the list are not really recommended, but you can try them if you find them at the right price.

The Toko coils are available from Digi-Key[3]. The same company also sells inexpensive crystals.

Summing things up

I hope my work encourages you to plug in your soldering iron. These designs are simple, fun to build, and easy to modify. You can get a lot of satisfaction per hour of assembly effort.

If you have problems or questions (other than where to find the parts), drop me a line and I'll try to help. (Please include an SASE.) But if you come up with improvements, don't write me; drop a line to Marty Durham, NB1H, at *HAM RADIO*, so he can print them and we can all share your findings.

References

1. Signetics Linear Data and Applications Manual, Volume II, 1985, page 5-3.
2. Signetics Application Note AN198 (included in above Manual).
3. Digi-Key, P.O. Box 677, Thief River Falls, Minnesota 56701. Order only: 1-800-344-4539 ($10 minimum).

Article A **HAM RADIO**

THE 4SQTRON COMPACT ANTENNAS FROM 160-10 METERS
NO TUNERS!
NO RADIALS!
NO RESISTORS!
NO COMPROMISE!
THREE EXCELLENT REVIEWS JUST DON'T HAPPEN BY CHANCE.
CALL US FOR A FREE CATALOGUE.
*See review in Oct 73, 1984
*Sept 73, 1985 *March 73, 1986
NEW LOCATION!
BILAL COMPANY
137 Manchester Dr.
Florissant, Colo. 80816
(719) 687-0650 ✓ 198

BATTERIES
Nickel-Cadmium, Alkaline, Lithium, Etc.
INDUSTRIAL QUALITY
YOU NEED BATTERIES?
WE'VE GOT BATTERIES!
CALL US FOR FREE CATALOG
✓ 199
E.H.YOST & CO.
EVERETT H. YOST KB9X1
7344 TETIVA RD.
SAUK CITY, WI 53583
ASK FOR FREE CATALOG
(608) 643-3194
MR. NICAD

CADDELL COIL CORP.
35 Main Street
Poultney, VT 05764
802-287-4055
BALUNS
Get POWER to your antenna! Our Baluns are already wound and ready for installation in your transmatch or you may enclose them in a weatherproof box and connect them directly at the antenna. They are designed for 3-30 MHz operation. (See ARRL Handbook pages 19-9 or 6-20 for construction details.)

100 Watt (4:1, 6:1, 9:1, or 1:1 impedence—select one)	$10.50
Universal Transmatch 1 KW (4:1 impedence)	14.50
Universal Transmatch 2 KW (4:1 impedence)	17.00
Universal Transmatch 1 KW (6:1, 9:1, or 1:1—select one)	16.00
Universal Transmatch 2 KW (6:1, 9:1, or 1:1—select one)	18.50

Please send large SASE for info



THE WEEKENDER

IMPROVING OPERATION WITH THE MFJ 989 TRANSMATCH

The **MFJ 989** transmatch provides great versatility for the money. With 240-pF variable capacitors and a 36-μH rotary inductor, the unit handles most loads down to 160 meters. However, you can improve its performance at 12 and 10 meters with two simple changes.

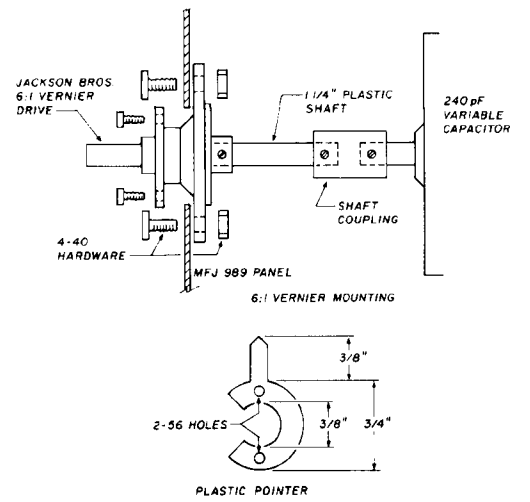
1. Remove the case top and check the rotary inductor. MFJ has used at least two different models. In my unit, the lower end (closest to front panel) of the coil was not grounded. Correcting this situation revealed another problem. The movable tap was grounded at the panel end, leaving a long path of low Q stray inductance. This reduced the available adjustable inductance at 10 meters. The fix is simple. Run a heavy ground strap from the movable tap terminal at the rear end of the inductor unit to ground. In my unit, the strap goes to a mounting lug on the chassis. The result is another half turn of available adjustable inductance, and the shape of the ground lead follows the general coil shape, yielding (I would guess) higher Q stray inductance.

2. The variable capacitors are difficult to tune for high reactance loads. Sharp settings result in back and forth overshoot. The solution is to install a pair of Vernier drives. I used a pair of 6:1 Jackson Brothers drives. Again, installation is straightforward and requires no disassembly other than removing the capacitor knobs. The steps are as follows:

a. After removing the case top and knobs, cut the capacitor shafts to a length of 1/2". This point is just about where the plastic part of the shaft begins. Save the plastic shafts for step d. (Note: if Verniers were to be installed during initial assembly, this cutting would be unnecessary. Only the plastic shafts would need trimming.)

By L. B. Cebik, W4RNL, 2414 Fair Drive, Knoxville, Tennessee 37918

FIGURE 1



Sketch of vernier mounting on MFJ 989 panel.

b. With a chassis hole punch, enlarge the shaft opening in the front panel to about 7/8". Carefully align this hole so that the shaft is dead center.

c. Using the drive as a guide, drill 4-40 (1/8" diameter) holes for the mounting wings of the drive. On older model 989s with capacitor reference numbers between 1 and 6, vertical alignment avoids obscuring any number. Newer models have finer markings, and the hardware will obscure something.

d. Cut the plastic remnants of the capacitor shafts to 1-1/4", and mount to the drives. This step restores adequate insulation between the capacitors and the panel assembly. Then install the drives loosely on the front panel to check alignment.

e. If the plastic shaft aligns very well with the capacitor metal shaft, loosen the assembly and install an ordinary 3/4" long 1/4" diameter shaft coupler to join the metal and plastic shafts. Then tighten down everything and check for capacitor binding during rotation. If binding occurs, or if alignment is not very good, install a flexible shaft coupler between the capacitor and the plastic shaft. This step goes smoothly if all cut shafts have been filed smooth. Remember to vacuum the filings from the transmatch case.

f. If the drive is equipped for a secondary marker (two screws into a brass plate), cut a marker pointer from thin, stiff plastic. Plastic file folder material is ideal; it's stiff, but can be cut with shears or an Xacto® knife. Then add the original knob, align the capacitor for mark 1 or 6 (or 10 on the latest models), and reclose the case.

The result will be easier capacitor setting with no overshoot beyond minimum SWR. This speeds up resetting the transmatch when changing bands. Outside of the 4-40 mounting hardware and small pointers emerging from behind the capacitor knobs, you haven't altered the appearance of the 989 at all. The improved operation of the transmatch makes this 2-hour effort well worth the energy.

The Jackson Brothers 6:1 Vernier dials (part no. 4511-DAF) are available through Radiokit, Pelham, New Hampshire. *Ed.*

Article B **HAM RADIO**

HI-PERFORMANCE DIPOLES

Antennas that work! Custom assembled to your center freq. as listed - advise # of center and each end - hang as Inverted V - horizontal vert dipole coaxial dipole commercial quality - stainless hardware - legal power - no trap high efficiency design

Personal check MO or C.O.D. (US)

MPD-5*	80-40-20-15-10M max performance dipole 87' long	$101ppd
MPD-2	80-40M max performance dipole, 85' long $82	95'-$56 ppd
HPD-3*	160-80 40M hi performance dipole 113' long	$78 ppd
SSD-6*	160-80-40-20-15-10M space saver dipole 71' long	$123 ppd
SSD-5*	80-40-20-15-10M space-saver dipole specify L. 42'-$105	52'-$106 ppd
SSD-4*	80-40-20-15M space saver dipole specify L. 46'-$93	60'-$ 96 ppd

*9-bands with wide matching range tuner.

SASE for catalogue of 30 dipoles, slopers, and space-saving, unique antennas

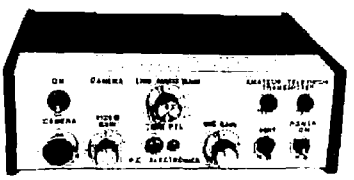
WOINN ANTENNAS
312-394-3414 BOX 393 MT. PROSPECT, IL 60056

196

AMATEUR TELEVISION

NOVICES: NOW YOU CAN TRANSMIT VIDEO WITH OUR NEW TX23-1

Did you know that you as well as all classes of licensed amateurs can easily transmit live action color and sound video just like broadcast TV with our TX23-1 transmitter. Use any home TV camera and/or VCR, computer, etc. by plugging the composite video and audio into the front 10 pin or rear phono jacks. Call or write now for our complete ATV catalog including downconverters, transceivers, linear amps, and antennas for the 70, 33, & 23cm bands.



Only $299

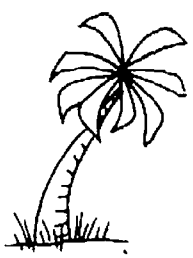
197

TX23-1 one watt ATV transmitter crystaled for 1289.25 MHz runs on 12-14 Vdc @ .5A. PTL T/R switching. 7x7x2.5". Transmitters sold only to licensed amateurs for legal purposes verified in the latest Callbook or with copy of license sent with order.

(818) 447-4565 m-f 8am-5:30pm pst.

P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006

Tom (W6ORG)
Maryann (WB6YSS)



29th ANNUAL

TROPICAL HAMBOREE

A.R.R.L. FLORIDA STATE CONVENTION

FEBRUARY 4-5, 1989

TAMIAMI PARK FAIR GROUNDS
10901 S.W. 24th Street (Coral Way), Miami, Florida
HOURS: 9 A.M.-5 P.M. SATURDAY • 9 A.M.-4 P.M. SUNDAY

FREE PARKING 15,000 VEHICLES •
1,000 INDOOR SWAP TABLES •
300 CAMPSITES WITH FULL HOOKUPS •

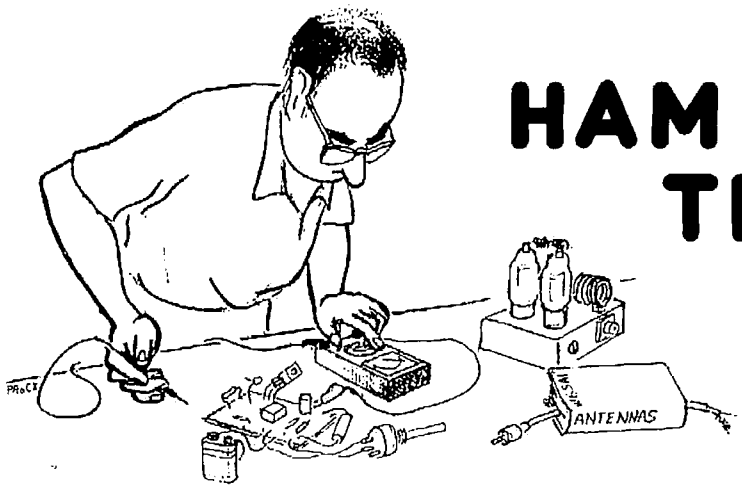
• 200 COMMERCIAL EXHIBIT BOOTHS
• COMPUTERS & SOFTWARE
• LICENSE EXAMS

Registration: $5.00 Advance – $6.00 Door. Valid Both Days. (Advance deadline January 30th.)
Swap Tables, 2 Days: $16.00 each. Power: $10.00 per User.
All swap table holders must have registration ticket.
Campsites: $12.00 per Day • Includes Water, Power, Sanitary Hookups & Showers.
(All RV vehicles, tent campers, vans, trailers welcome – no ground tents, please.)

Make Checks for Registration, Swap Tables & Campsites Payable to:
Dade Radio Club & Mail As Follows:

Tickets & Hotel Info Only: Evelyn Gauzens, W4WYR, 2780 N.W. 3rd St., Miami, FL 33125
Swap Tables, RV, Tickets & Hotel: John Hall, WD4SFG, 8670 S.W. 29th St., Miami, FL 33155
RV & Tickets Only: Dick Leisy, W4OOH, 650 W. 63rd Dr., Hialeah, FL 33012
Exhibit Booth & General Info: Evelyn Gauzens (address above) or Call (305) 642-4139 or (305) 233-0000

(BROCHURE WITH FULL DETAILS AVAILABLE DECEMBER 1st)



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

The radio boys in the Pacific, or, working DX for Uncle Sam

The year was 1934. Many thoughtful Americans felt that war with Japan was inevitable, but the international political atmosphere tied their hands. Japan, in defiance of treaties, was fortifying Micronesia and busy turning the island of Truk into a large naval base. Other Japanese bases existed at Koror, Ponape, and Saipan. The military analysts in Washington thought the next thrust of Japanese military power might be in the direction of Hawaii, though a smattering of small islands lay in the path. The United States was faced with the problem of protecting and converting these islands into advance air or naval bases, without upsetting relations with Japan.

The Pan-American "smoke screen"

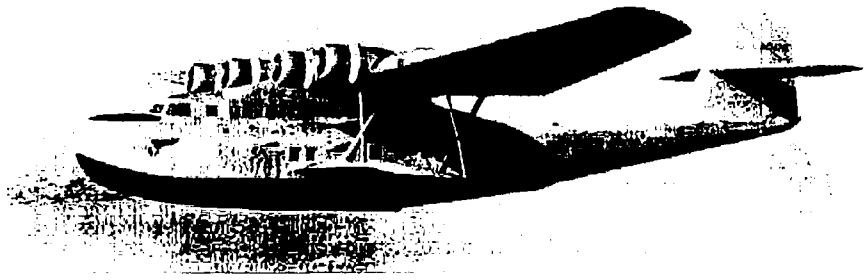
The proposed flights of the legendary Pan-American Airways flying boat "China Clipper" (see **Photo A**) provided a smoke screen behind which American preparations in the Pacific could take place without arousing the Japanese government. The huge flying boat with its requirements for island refueling bases was thought to be the ideal cover for preliminary investigation and eventual fortification of the islands to the west of Hawaii. The Clipper would fly on a regular commercial schedule from San Francisco to Macao or the Phillippines, stopping at various U.S.-controlled Pacific islands for refueling and to allow the passengers to rest. The uninhabited islands had to be surveyed and determination made as to which ones would be suitable as landing sites for the Clippers. A deep lagoon was needed on each island, with sufficient land area to accomodate the necessary support facilities. Survey crews were hired quickly to start the project. This is where Radio Amateurs played their fateful role.

The China Clippers

The Martin M-130 flying boats were titans. Over 90-feet long and with a 130-foot wing spread, the four-engine, 26-ton giants were the first planes powerful enough to carry their equivalent weight as payload. They could fly an astounding 3,200 miles nonstop at 130 miles per hour. No other aircraft could duplicate this feat. The time was ripe for these Clippers to island-hop from the American West Coast to the Orient. Aided by covert military funds, the U.S. government set about establishing island bases to accomodate the flying boats.

Each flying boat was equipped with duplicate shortwave receivers and crystal-controlled transmitters (CW) in addition to a battery-operated emergency trans-receiver. Long-wire

PHOTO A



The Martin M-130 "China Clipper" in flight over San Francisco Bay, bound for Honolulu, Hawaii. The 26-ton flying boat carried 16 passengers and took 18 hours for the first leg of the flight to Hawaii. One-way fare to Honolulu was $360. Round trip to China and back was $1600.

antennas were strung between the aircraft's nose and tail. A group of frequencies in the 3-10 MHz region were allocated to the Pacific chain of bases with whom the Clippers could easily and quickly communicate. The Clippers' flights could be tracked across the Pacific by direct CW contact every half hour, as well as by direction finders placed on the islands.

Island colonization

One of the first steps to establish ownership of the islands was the Coman Oceanographic Expedition of 1935. Kenneth Lum King, K6BAZ was with this expedition. He was replacing K6GNW who had been stationed on Howland Island in connection with the tragic flight of Amelia Earhart. K6ODC was on Johnston Island, while K6INF was on Baker Island. Howland, Jarvis, and Baker Islands were being "colonized" to justify a U.S. claim on the group. The claim was supported by the fact that Americans had visited the islands between 1860 and 1880 to dig guano (fertilizer). In addition to lazing in the sun, the radio Amateurs handled commercial traffic and worked DX on 7 and 14 MHz.

Other tiny islands were also being colonized by American expeditions. They, too, had hams serving as radio operators. Kingman Reef, Canton Island, Christmas Island, and Olosenga Island (Samoa) were about to be put on the air. The islands of Hull, Swain, Atafu, and Puka Puka were also investigated as possible military sites.

Beginning in 1934, Pan-American and U.S. government crews started to work on air bases the Navy needed but couldn't get. Baker, Jarvis, and Howland Islands were claimed by the British, but in 1935 the U.S. State Department decided not to waste time discussing the matter with the British. It began to colonize the islands immediately instead. Commercial aviation supplied the "cover story".

Canton Island—American or British?

Each island base was to be self-sufficient, complete with maintenance facility, radio and beacon stations, and a weather station. The Howland Island airstrip was built first as a navigation aid for the Earhart flight. The supply ship "Itaska" was stationed near Howland as the principal navigation system for the flight. The loss of the Earhart plane and the radio navigation problems of the "Itaska" convinced the Navy that only permanent, well-organized facilities would do. A better island was needed; that turned out to be Canton Island.

The stage was set. Americans landed on Canton Island in February 1935, only to find British settlers there. A peaceful truce came about, but in May 1939 a British cruiser blocked the American supply ship and prevented it from reaching the island. Diplomatic cables flew back and forth between Washington and London, and the cruiser eventually sailed away. Sovereignty was placed in abeyance.

While the international political game was being played between America and England, Japan watched the colonization of the islands with apprehension. These islands would be used as advance bases for the forthcoming war with Japan! The Japanese Navy began to study how to eliminate these danger spots. Perhaps the best way would be to bypass them with a direct attack on the Hawaiian Islands...

The islands are Americanized

Once the islands were declared U.S. territory, the Federal Communications Commission quickly assigned prefixes:
KB6 (Guam) previously OM1 and K6
KC6 (Wake)
KD6 (Midway)
KE6 (Johnston)
KF6 (Baker, Canton, Howland, and Phoenix Islands)
KG6 (Jarvis and Palmyra)
KH6 (Hawaii, previously K6).

Even so, the situation was confusing. Some of the islands were under the control of the Department of the Interior (Jarvis, Baker, and Howland), while others were supervised by the Commerce Department. Others had no direct supervision other than that of the colonists, guided by the U.S. Navy.

During 1940-1941, while American Amateurs were banned from working foreign countries, the new Pacific islands provided a welcome source of DX. Most of the island hams worked on 7 or 14-MHz CW; a few of them were on 14-MHz phone. Some of the stations heard on the air during that period are listed in table 1.

TABLE 1

Partial list of Radio Amateur activity in the Pacific (1935-1940):

KB6-Guam
KB6RWZ
KB6CBN

KC6-Wake Island
KC6QA
K6LHA/KC6
K6TE/KC6

KD6-Midway Island
KD6FOU
KD6QHX

KE6-Johnston Island
KE6SRA

KF6-Baker, Canton, Howland, and Phoenix Islands
K6BAZ
K6JRN
K6HCO
K6ODC
K6JRN
K6JEG
KF6ROV
KF6SJJ
KF6JEG
KF6PUL
W7DBR/KF6

KG6-Jarvis and Palmyra Island
K6ODC
KG6MV
K6GNV/KG6

War!

By late 1941, the new Pacific possessions were highly visible on the Amateur bands. There was talk of other exotic islands ready to come on the air any day, but the advent of World War II quickly put the hams off the air. Most of the islands were evacuated to protect the personnel and the installations were destroyed. Only Midway and Wake Islands were

MICROWAVE COMMUNICATION POSITIONS

MICROWAVE RADIO CORP is experiencing rapid growth in the telecommunication field and is seeking to fill the following positions.

Microwave Radio Development Engineer

Individual must be experienced in design of radio communication equipment with strong background in general circuit design and communication theory. Actual microwave experience desirable, but not necessary. Hands on design experience as well as experience with introducing new products into production required. Positions exist for several levels within the engineering group.

Quality Control Engineer

Position requires highly motivated individual with electrical engineering background. Responsibilities include working with company top management on a variety of projects such as setting up Q.A. standards and reporting procedures for the company; working with and evaluating vendors and resolving quality related problems. This is both a staff and hands on position.

Product Line Manager

Opening for a unique individual to assume total product responsibility for small, low volume, semi-custom steerable and tracking microwave antenna system products used in television electronic news gathering. Responsibilities include: inventory maintenance; supervision of electro-mechanical techs; trouble-shooting microprocessor based antenna controllers; design of control circuitry and software modifications for custom applications. Should be proficient in microprocessor control system and telephone modems. Basic understanding of microwave receiving and transmitting systems required. Due to the custom nature of this product, customer contact is required.

Operations Manager

Will have responsibility for all aspects of scheduling, material control, manufacturing and test for a product line of microwave transmitters and receivers. Individual should have a minimum of 5 years manufacturing experience with a technical background.

Senior Buyer for New Product Area

Experienced professional with a minimum of 5 years experience purchasing electronic components, mechanical parts and sub-assemblies. Technical background and experience in the radio communication industry highly desirable. Will be responsible for purchasing and assisting in vendor selection and setting up long term purchasing agreements with various suppliers.

RF Test Technician

Minimum of 3 years experience in test and alignment of microwave modules such as multipliers, sold state microwave amps, filters and mixers.

Interested persons should send resumes to the attention of Mary Morancie or call (508) 459-7655 for further information.

Microwave Radio offers competitive pay and excellent benefits package. Microwave Radio is an equal opportunity employer.

MICROWAVE RADIO corporation
847 Rogers Street
Lowell, MA 01852

thought to be of any use to the Navy in the long, hard days ahead.

Post-war Amateur operation

As soon as Amateurs were allowed back on the air, some of the Pacific islands became active. In particular, Canton, Wake, and Christmas Islands were represented on 20-meter phone. An interesting situation developed on Canton Island (re-christened with the new prefix KB6). British settlers arrived to strengthen the British claim on the islands. The American contingent was represented by KB6AD (Ken Neifert) and the British by VR2AZ/VR1 (Don Schroder). As far as DXCC was concerned, Canton Island counted for two countries, depending upon whom you worked!

TABLE 2

Present day listing of prefixes from the Pacific.

KH2, (KB6).....Guam
KH9, (KW6).....Wake Island
KH4, (KD6) .....Midway Island
KH3, (KD6) .....Johnston Island
KH1, (KF6).....Baker, Canton, Howland, and Phoneix
KH5, (KG6) .....Jarvis and Palmyra Island

The end of the China Clippers

The last China Clipper flight took place in April 1946. Newer, four-engine post-war transports could fly quicker, carry a heavier load, and cost less to operate than the old flying boats. Most of the island bases were no longer needed. The facility on Canton was abandoned in 1945, but partially retained as a weather station. Later, it was used as a down-range tracking station for the U.S. Air Force. By 1970 this activity ceased, but the island is still under joint U.S.-British administration.

Now most of the islands are deserted. Wind, wave, and sand have obliterated the old bases. Jet aircraft make contrails over the islands as they fly past locations once thought vitally important in the hectic, pre-war days, but now merely relics of a forgotten period of American history.

An occasional DXpedition visits one or two of the islands. The F.C.C. has assigned new prefixes to the islands (see **table 2**) and hopeful Dxers still keep an ear open for radio activity from the little spots of sand that loomed so large in pre-war America planning.

The "Dead Band Contest"—"Elementary, my dear Watson"

In my July 1988 column I challenged my readers to identify a quotation from a famous work of fiction, thus proving that alert and active hams are not "couch potatoes", but are avid readers when the band is dead. The quote was: "You have been in Afghanistan, I perceive."

I was pleased and gratified at the many correct responses to this quiz and I was impressed by the depth of knowledge of the "Sacred Writings". As Bob Rosenquist, WØEHF, put it, "These were the first words spoken to John H. Watson, M.D., late of the Army Medical Department, by Sherlock Holmes in January 1881, in the laboratory at St. Bartholomew's Hospital in London."

Harry Hyder, W7IV, also illustrated his knowledge of "The Canon" and informed me he was a member of the "Sherlock Holmes Wireless Society."

Congratulations to the other readers who were kind enough to enter this contest. Within the first week of publication of the July issue of *HAM RADIO*, the following had correctly identified the quotation. The asterisk (*) after the call indicates the individual had exceptional knowledge of the famous works of Sir Arthur Conan Doyle.

George Marts, WØTDH; George Goldstone, W8AP(*); Donn Baker, WA2VOI; Bob Harmiston, WB6JOP; Dan Pierson, W6NTX(*); Fred Linn, W9NZF; Bill Calderwood, K1CT; Steve Trapp, ND4G; Russ Webster, K6WM; John Mise, AA6FK; Mike

Helm, WC5Z; Carl Scherer, VE3MDM; Ed Wetherhold, W3NQN; John Peak, KE6HS; "Doc" Roberts, K9BX; Ralph Turner, W8HXC; Bob Locker, W9KNI; Ken Morgan, KC5DW; Bob Houf, KD9UX; Steve Twiggs, KM7U; Gary Grebus, K8LT.

Another "Dead Band" Contest

Smart readers, eh? Well, try this one on for size. Identify the subject, verb, and object of this portion of the following popular song:

"Oh, say, can you see, by the dawn's early light, what so proudly we hailed at the twilight's last gleaming"

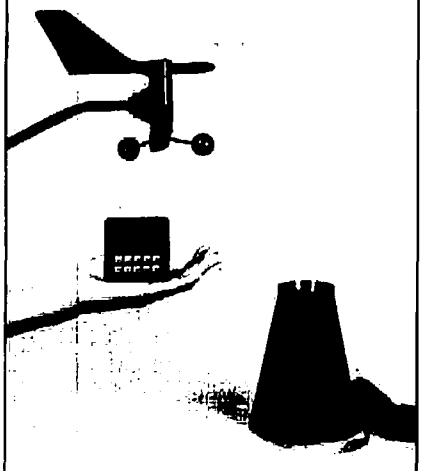
This quiz was given by Jon Carroll in his column in *The San Francisco Chronicle* of July 1, 1988.

References

1. Ronald W. Jackson, "China Clipper," Everest House, New York, 1980.
2. Kenneth Lum King, "Pounding Brass for Uncle Sam," *Radio*, November 1938, page 18-22.

Article C **HAM RADIO**

WORLD'S SMALLEST——WEATHER STATION



THE AMAZING WEATHER COMPUTER THAT YOU CAN HOLD IN THE PALM OF YOUR HAND.

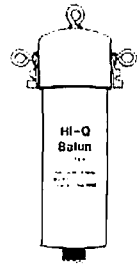
DIGITAR's new TWR-3 Micro Weather Station includes a computer, precision wind vane and speed sensor with mounting hardware, and 40 feet of cable. For only $159.95. With the optional, automatic-emptying RG-2 Rain Collector ($49.95) you can even monitor rainfall!

- WIND SPEED
- WIND DIRECTION
- WIND CHILL
- WIND GUST RECORD
- TEMPERATURE
- HI/LOW TEMP RECORD
- RAINFALL (Optional)
- TIME OF DAY
- AUTO SCAN
- METRIC / STANDARD
- NICAD READY
- ONE YEAR WARRANTY

MAGNAPHASE INDUSTRIES, INC.
1502 PIKE STREET N.W.
MADE IN U.S.A. AUBURN, WA 98001 M/C & VISA
ORDERS ONLY: 800-322-1502
INFORMATION: 206-735-0374 FAX: 206-735-9044

192

HI-Q BALUN



- For dipoles, yagis, inverted vees, and doublets
- Replaces center insulator
- Puts power in antenna
- Broadbanded 3.46 MHz
- Small, lightweight and weatherproof
- 1:1 or 4:1 impedance ratio
- For full legal power and more
- Helps eliminate TVI
- With SO 239 connector
- Built-in DC ground helps protect against lightning

Only $14.95

HI-Q BALUN 9:1 impedance ratio 5KW PEP

ONLY $34.95

HI-Q ANTENNA CENTER INSULATOR



- Small, rugged, light-weight, weatherproof
- Replaces center insulator
- Handles full legal power and more
- With SO 239 connector

$6.95

SHORTY ALL-BANDER



- Completely factory assembled, ready to use
- Small, lightweight, weatherproof, sealed shorteners with stainless steel eyelets
- Heavy 14 7/22 gauge stranded copper antenna wire to survive those severe storms
- Center fed with 100 feet of low loss, 450 ohm balanced transmission line
- Includes center insulator with an nylon hook for center support
- Includes custom molded insulators molded of top quality material with high dielectric qualities and excellent weatherability
- Complete installation instructions included
- Overall length 70 feet, less when erected as an inverted vee or sloper
- Handles 2 kw PEP & covers 160 through 10 meters
- May be trimmed to fit small city lots

Only $39.95

The ALL-BANDER DIPOLE, *fully assembled overall* length 135 feet with 100 feet 450 OHM feedline

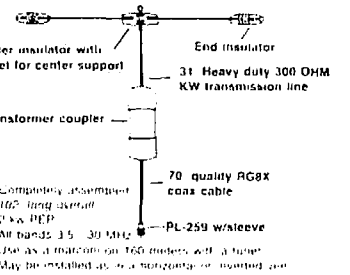
$29.95

DIPOLES

MODEL	BANDS	LENGTH	PRICE
Dipoles			
D-160	160	260'	$36.95
D-80	80/75	130'	31.95
D-40	40/15	66'	28.95
D-30	30	46'	28.95
D-20	20	33'	27.95
D-15	15	22'	26.95
D-10	10	16'	25.95
Shortened dipoles			
SD-80	80/75	90'	35.95
SD-40	40	45'	33.95
Parallel dipoles			
PD-8010	80,40,20,10/15	130'	43.95
PD-4010	40,20,10/15	66'	37.95
PD-8040	80,40/15	130'	39.95
PD-4020	40,20/15	66'	33.95
Dipole shorteners-only same as included in SD models			
S-80	80/75		$13.95/pr.
S-40	40		12.95/pr.

All antennas are complete with a HI-Q BALUN (HI-Q Antenna Center Insulator for Models including 160 meters), No. 14 7/22 stranded hard drawn copper antenna wire, insulators, 100' 450lb. test nylon antenna support rope, rated for full legal power.

G5RV



- Completely assembled
- 102' long overall
- 2 kw PEP
- All bands 3.5 - 30 MHz
- Use as a inverted vee on 160 meters with a tuner
- May be installed as a horizontal or inverted vee configuration

Only $49.95

SLOPERS

MODEL	BANDS	LENGTH	PRICE
SLA-I	160,80,40	60'	$49.95
SLA-II	80,40	40	44.95
SLA-III	80,40,20,10	27	69.95

DIPOLES

MODEL	BANDS	LENGTH	PRICE
Half-sized dipoles			
HSD-160	160	130'	$49.95
HSD-80	80	68	46.95
HSD-40	40	34	44.95
Loaded dipoles - using coils			
LD-I	80,40	80	$59.95
LD-II	160,80,40	122'	79.95
LD-III	80,40,20,10	53	89.95
LD-IV	160,80	164	69.95
LD-V	160,40	115'	64.95
LD-VI	80,40	78'	59.95
Trap dipoles			
TD-2010-2	20,15,10	28	$49.95
TD-2010-4	20,15,10	25	64.95
TD-4010-2	40,20,15,10	57'	54.95
TD-4010-4	40,20,15,10	48	74.95
TD-8010-2	80,40,20,15,10	108'	59.95
TD-8010-4	80,40,20,15,10	99'	79.95
TD-8010-6	80,40,20,15,10	84'	99.95
TD-16080-2	160,80	210'	71.95
TD-16010-8	160,80,40,20,15,10	148'	129.95
Suffix number indicates number of traps			
Windoms			
Standard windom			
	80,40,20,15,10	130'	$47.95
Windom with tuned feeder			
	80,40,20,15,10	130'	49.95
Super Windom-optimized for 80 and 40 meters			
	80,40,20,15,10	130'	54.95
Trap wire verticals (may also be used as Slopers)			
TV-2010-1	20,15,10	15'	$39.95
TV-4010-1	40,20,15,10	29'	44.95
TV-8010-3	80,40,20,15,10	44'	67.95
TV-16010-4	160,80,40,20,15,10	75'	79.95
Suffix number indicates number of traps			
Dipole shorteners-only, same as included in HSD models			
SDC-160	160		$19.95/pr
SDC-80	80/75		10.95/pr
SDC-40	40		17.95/pr

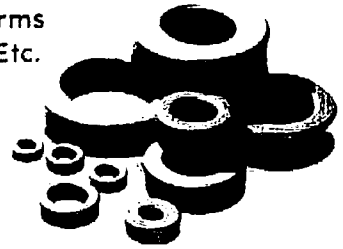
Antenna Accessories-available with antenna orders	
Nylon guy rope, 450lb. test, 100 feet	4.95
Molded dogbone type antenna insulators	1.00/pr.
SD-239 coax connectors	.65
PL-259	.75
UG 175 or UG 176 reducer sleeves	.25
No. 14 7/22 stranded hard drawn copper antenna wire	.08/ft.

193

ALL PRICES ARE UPS PAID CONTINENTAL U.S.A.
AVAILABLE AT YOUR FAVORITE DEALER OR ORDER DIRECT FROM
Van Gorden Engineering • P.O. Box 21305 • South Euclid, Ohio 44121
DEALER INQUIRIES INVITED

Iron Powder and Ferrite
TOROIDAL CORES

Shielding Beads, Shielded Coil Forms
Ferrite Rods, Pot Cores, Baluns, Etc.



Small Orders Welcome
Free 'Tech-Data' Flyer

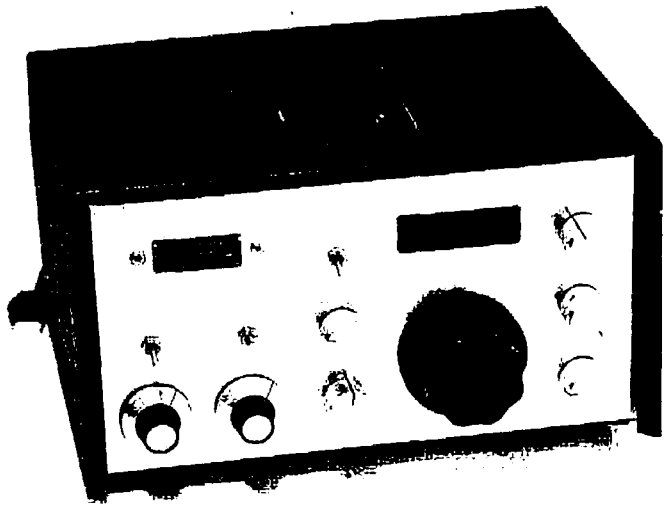
AMIDON Associates Since 1963

12033 Otsego Street, North Hollywood, Calif. 91607

194

THE PEPPERDYNE RECEIVER

Build this six-part receiver as a series of weekend projects



By Jim Pepper, W6QIF, 44 El Camino Moraga, Orinda, California 94563

There have been many articles on receiver construction. Some were good, some were beyond the capability of the average homebrewer, and some lacked sufficient information to complete the construction (e.g., pin information on special ICs and on troubleshooting). A receiver can be quite an undertaking if you're not given enough data. I've also found that it can take a substantial time investment to complete the project.

I decided to design and build a receiver that, although not in the same class as the present commercial receivers, would have some of their features and comparable performance. But most important, the builder would be able to repair it. Although this receiver is not a weekend project, it's designed to be built in sections; each takes about a weekend to build. To fulfill these requirements, I had three goals to meet: the circuitry had to be simple, be easily serviced or modifed, and use readily available parts.

Circuit description

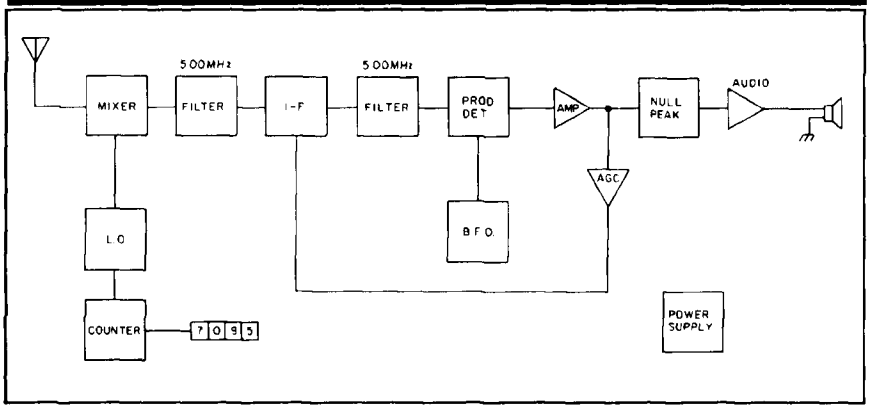
The receiver consists of six basic sections: the mixer, the local oscillator, the i-f section, the audio board, the counter board, and the power supply.

The mixer is a dual-gate MOSFET 40673 that uses a single coil to tune from 40-160 meters. A fixed capacitor is switched in parallel with the mixer-tuning capacitor to cover the 160-meter band. Using a single coil simplifies the coil-switching circuitry. The antenna is coupled to this coil through a series-tuned trap to reject 5 MHz, the frequency of the i-f. The 5-MHz trap works well as a notch filter rejecting the 5-MHz WWV broadcast; a front panel switch is provided to shunt out the trap and allow WWV reception.

The local oscillator is a standard Colpitts circuit using a MPF102 JFET. The circuit is tuned by a varicap diode and a ten-turn potentiometer. The varicap capacitance is a nonlinear function of the applied voltage, making the frequency change per turn of the tuning pot different at one end of the dial from the other. I have compensated for this variation by using a technique known as "pot loading." A resistor is connected from the pot arm to ground and, with the right choice of resistance, the variation can be greatly reduced. (This method can also be used to give a pot an output approaching an audio taper from a linear pot.)

The local oscillator operates 5 MHz above the incoming signal and has three coils to cover the three bands. In

FIGURE 1



Complete block diagram of the receiver.

effect, there are four bands covered with the 75/80-meter band handled by one coil. The actual frequency range covered by each coil is up to you.

Using a varicap diode for a tuning device requires that the tuning voltage source output be very clean. The LM723 voltage regulator is ideal. It's also better to use a ten-turn cermet pot for this circuit, because some wire wound pots produce objectionable turn-to-turn noise when tuning. I used a 100k pot. Any value from 10k to 100k will work, but you must use a different pot-loading resistor.

The i-f amplifier stage consists of an MC1350 IC that operates at 5 MHz with a two-pole ladder-crystal network on both the input and output. I experimented first with a single two-pole network and found the skirt selectivity very poor.[1,2,3] I then tried a three-pole network to find that crystal matching was very critical and the desired bandwidth was difficult to achieve. Finally, I decided to try the input/output configuration; it gave very good rejection and the bandwidth needed for phone operation. I chose the 5-MHz frequency because of the availability of low-cost crystals and the WWV reception capability. You can use other frequencies, but you may have to alter the network components to achieve the desired bandwidth characteristics.

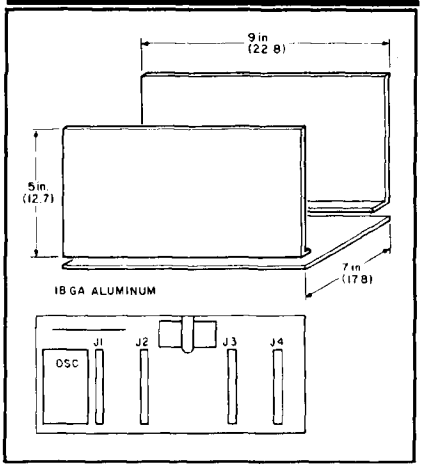
The MC1350 provides about 50 dB of gain and an AGC range of 60 dB. The AGC voltage is derived from the audio signal and there is little difference in the audio output level of signals registering from F2 to F9. I included an i-f gain control, but I don't use it very much.

The product detector in this receiver is a CA3028. I experimented with a number of different detectors and found the CA3028 to be the best from a gain standpoint. It also required the least number of parts. The BFO for the product detector is generated by a 5-MHz crystal oscillator. To keep the circuitry simple, only lower sideband reception is available. This is no real problem since 99 percent of the stations on the three bands use the lower sideband for transmission.

The audio section consists of an audio amplifier, an AGC circuit, a peak-null filter circuit[4], and a LM380 power amplifier. The peak-null circuit can give either a sharp rejection of a given frequency, or peaking — which is very effective on CW operation. The selected frequencies are variable and controlled from the front panel. The two are independent of each other.

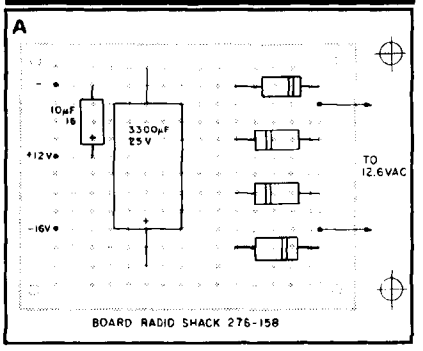
The counter circuit, with a few changes, was copied from an old issue of *Popular Electronics*[5]. The circuit consists of a timebase and a programmable counter that allows the i-f frequency to be subtracted from the local oscillator frequency, giving the frequency of the incoming signal. The circuit is designed to display to the kHz level. By adding another divide-by-10 counter, the display will read to the 100-Hz level. The two ranges are accessed by a switch on the front panel.

FIGURE 2

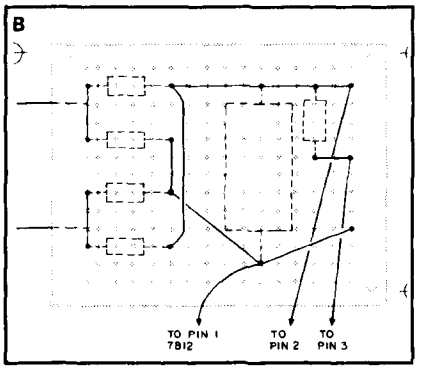


Dimensions of the receiver cabinet, and pc board placement within the cabinet.

FIGURE 3



Power supply parts placement guide.

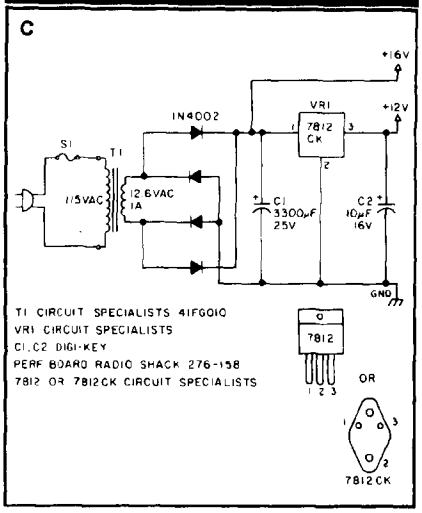


Power supply foil-side connections.

Receiver construction

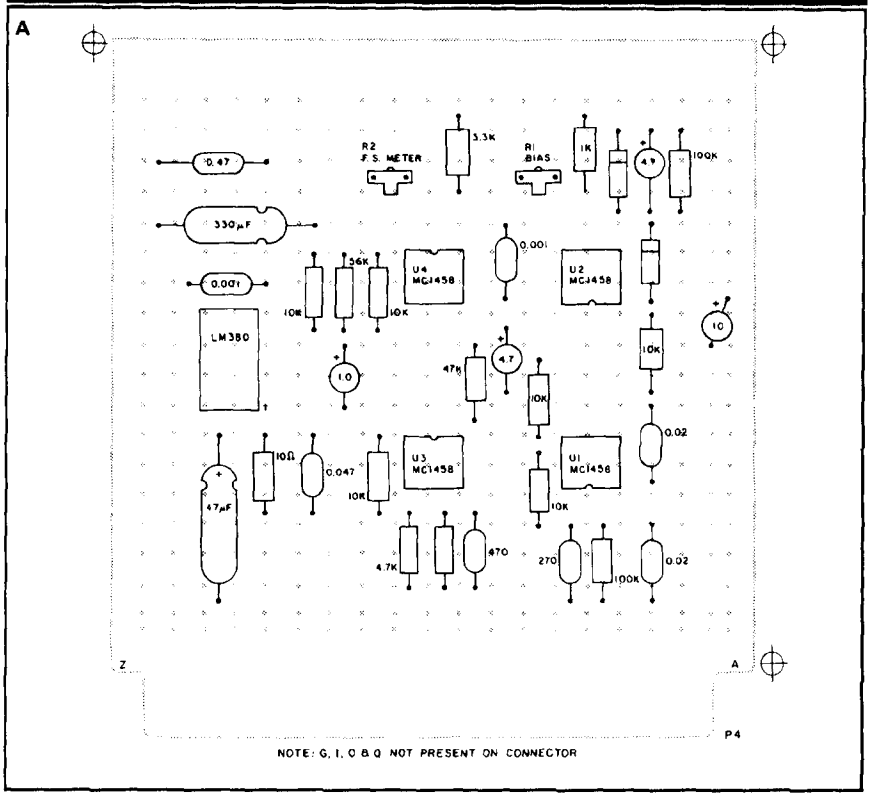
For serviceability, the receiver is broken down into six parts; four are made on plug-in boards. The fifth board, the local oscillator, is mounted on the chassis for stability and the sixth is the power

FIGURE 3



Power supply schematic.

FIGURE 4



Audio board parts placement guide.

supply. See fig. 1, the block diagram.

The parts can be purchased from the supply houses listed on the figures. (You may find many of them in your junk box.) I would advise you to send for the suppliers' catalogs before ordering; some have a minimum purchase amount.

Construction hints

The tools required are those ordinarily used for homebrew work. I would suggest that your soldering iron have a small tip to be used on the pc boards. These boards, obtained from Radio Shack (no. 276-152), are similar to vector boards and come with multiple holes and pads for mounting parts.

The power supply pc board and transformer are mounted on the rear panel of the cabinet, which also acts as a heat sink for the 12-volt regulator. The plug-in board sockets (Radio Shack no. 276-1551) mount on the bottom plate with 0.5″ spacers. The pc board components are mounted on push-in terminals from Circuit Specialists (no. T42). Before mounting any parts, I tinned the fingers on the board that was used for interconnects. Do this by first heating and then wiping each finger with a cloth. The tinned surfaces should be thin.

My cabinet came from Radio Shack, but it is no longer available. In order to house the pc boards, the cabinet height must be at least 5″, and to house the rest of the components, at least 7″ deep by 9″ wide. (See **fig. 2.**) Before starting on the pc boards, I suggest that you mount and wire the parts for the front and rear panels and the sockets for the boards, so each pc board can be checked for operation as it is completed. The 7812 voltage regulator is mounted directly to the rear chassis. No isolation is required.

Power supply

Build the power supply shown in fig. **3A-C** first. The board is attached to the rear panel by two 0.5″ spacers over the 7812 voltage regulator. When completed, the AC power can be applied and the power supply output voltages can be checked with a voltmeter for proper operation.

Audio board

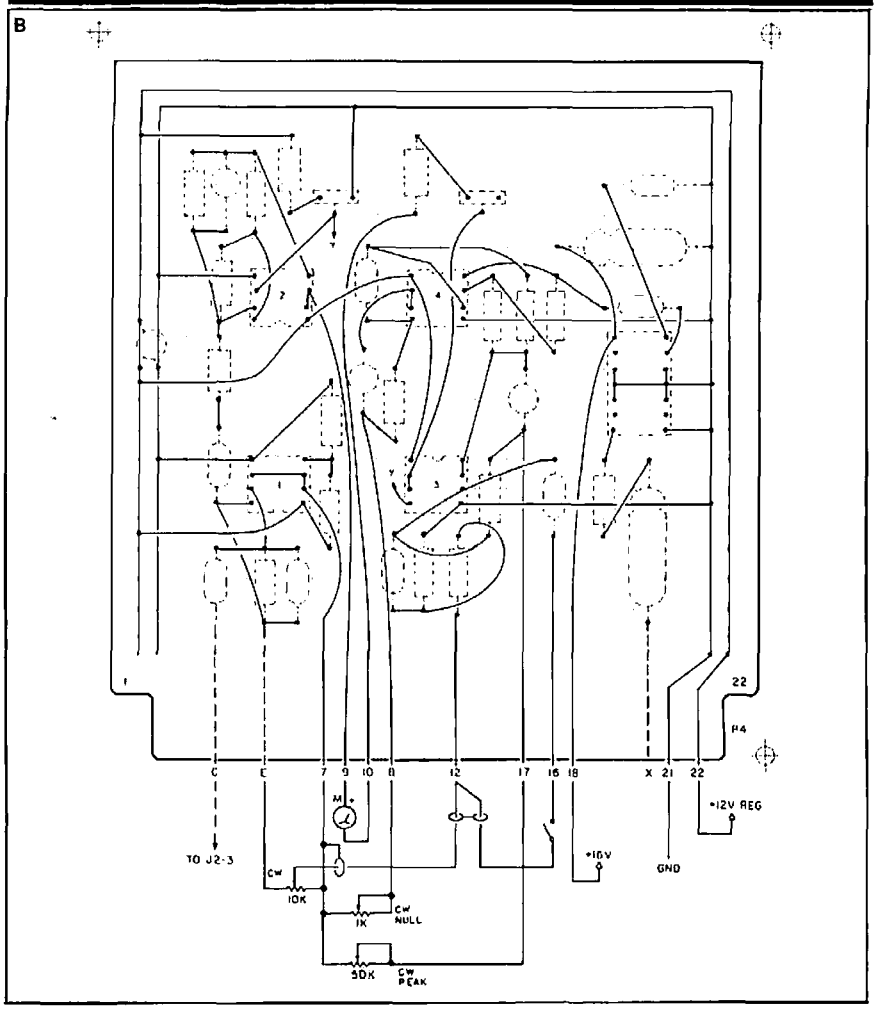
Before starting on any of the following boards (**figs. 4A, 4B, 4C**), I would suggest that you make a copy of the assembly drawings. You can mark the components and wires you have installed on these sheets. This makes it easier to stop your work and then pick up where you left off.

Audio board construction

The audio board consists of a preamplifier, an audio-derived AGC, an S-meter driver, a peak-null circuit, and an LM380 power amplifier. The LM380 and similar amplifiers are prone to oscillate under certain loads. I found that a 10-ohm resistor in series with the speaker makes the circuit stable, with little output loss. The voltage for the output is obtained from the unregulated power supply (16 volts) to allow greater output without distortion.

The audio-derived AGC controls the gain of the MC1350 i-f amplifier. An offset voltage of 5 volts is required when there is no signal and the AGC voltage moves in a positive direction for an incoming signal. This offset is generated on the audio board. The S meter is also connected to this voltage. No zero

FIGURE 4



Audio board foil-side connections.

adjustment is required with this design; however, a full scale adjustment is provided. The values shown are for an old CB S meter with a 250 μA movement. You can use any movement up to 1 mA, but you'll have to reduce the series resistor.

Following the parts layout for the audio board (**fig. 4B** and **C**), mount the IC sockets and push-in terminals as indicated. Check the size of your components; they may be different than the type I used. This is especially true for capacitors. Mount all of the components on the push-in terminals. This makes identification of points for wiring the other side of the board easier. Save the wire clippings; they can be used for jumpers on the wire side of the board.

Next, wire all short jumpers. The same wire can be used on longer leads, if there are no crossovers. Where there are crossovers, I used wire-wrap type. Remember to mark off all work done.

Testing the audio board

Insert the required ICs into their sockets and plug the pc board into socket J4. Turn on the power and check the voltages against the schematic. Set R2 (the S-meter sensitivity pot), to maximum resistance. The peak switch (S1) should be closed, and the null pot set at the maximum clockwise position. You'll need to connect a speaker for this test. If an audio oscillator is available, connect it to pin C on the pc socket, J4. A 20 mV peak-to-peak 1-kHz signal should

GILFER SHORTWAVE

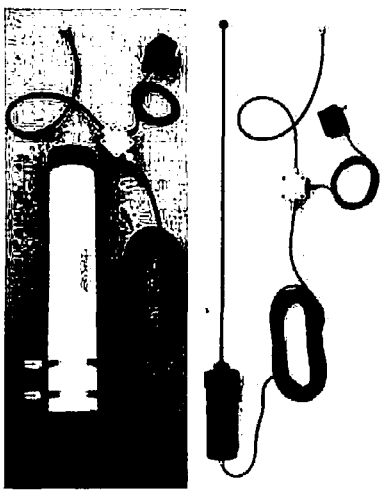
"First in Shortwave, first in service to the world's SWLers"



Datong Multi-Mode Filter

It separates the signals you want from those you don't – with multi functions. Fully automatic notch filter removes heterodynes and other steady tone interference. Independent low and high pass filters stop "monkey chatter" and other off-tune interference, tuning 200-3500 Hz. Second notch filter manually tunes 200-3500 Hz. For speech, all filters work independently for flexibility. A special mode for CW and RTTY combines the filters into a 12-pole filter with super skirt selectivity and non-interacting controls. Works with any receiver, easy to install. Features 29 ICs with latest switched capacitor filter technology.

FL-3 ..... **$229.95 (+$4)**



Dressier Active Antennas

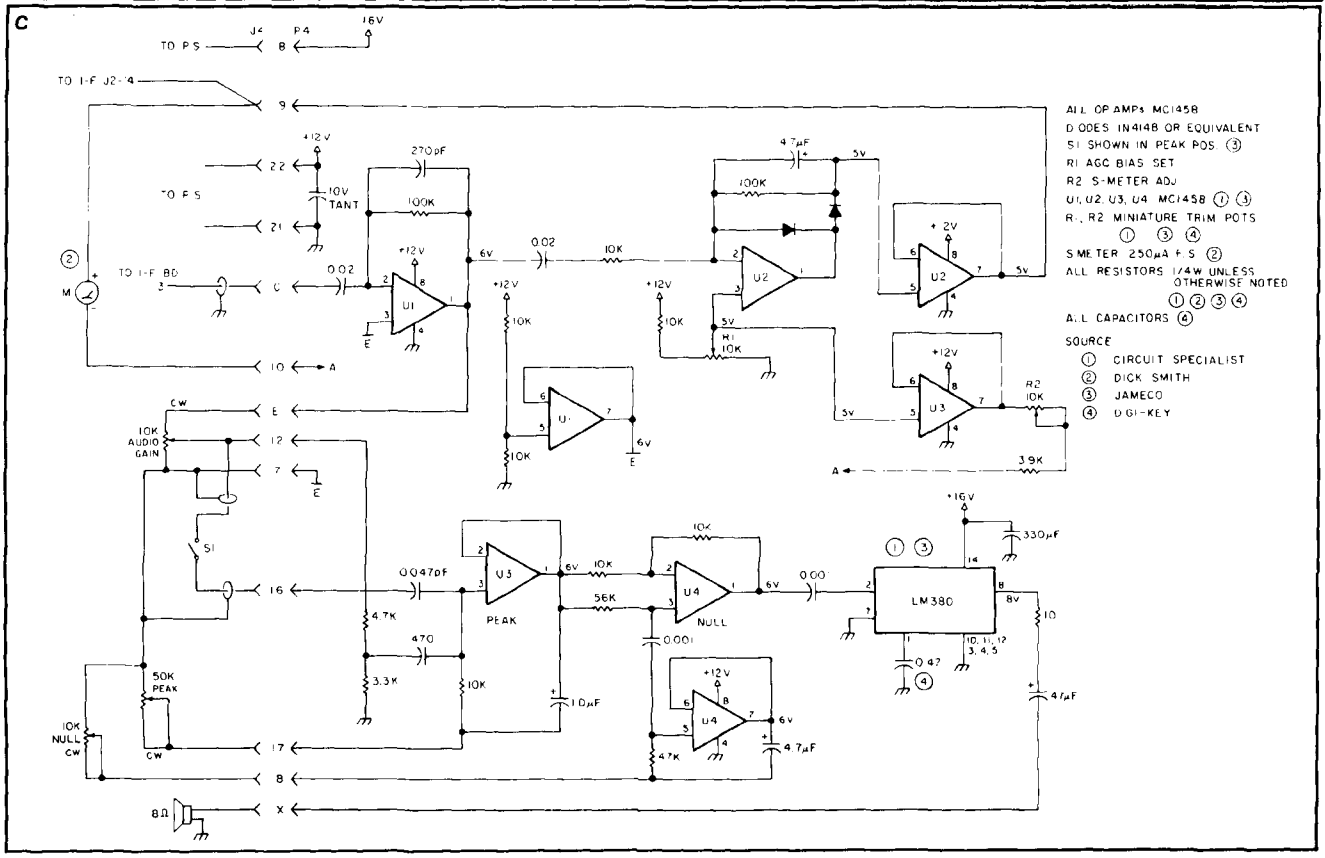
Model ara 30 ..... **$159.95 (+$8)**
For HF use up to 30 MHz and more. Features low noise field effect transistor acting as an impedance transformer together with a high linear CATV transistor. A push-pull amplifier with noiseless negative feedback produces high linearity for low noise. Installs vertically, outdoors or in. Includes 26' cable, interface, and AC adaptor.

Model ara 900 ..... **$189.95 (+$8)**
For VHF-UHF and Scanners. Range 50-900MHz and more. Has low noise high gain 2-stage amp. With 1 gHz bandwidth. Gain is 15-16dB. Mounts indoors or out. Includes 26' cable, interface, and AC adaptor.

ORDER PHONE: 1-800-GILFER-1
Prices subject to change w/o notice
GILFER SHORTWAVE
52 PARK AVE. PARK RIDGE, NJ 07656
Ph 201/391-7887

190

FIGURE 4



Audio board schematic.

drive the audio to full output. The S meter should also vary as a function of the input signal. If no oscillator is available, touch your finger to pin C. You should hear a loud hum.

Building the i-f board

The i-f board construction, shown in **figs. 5A-C**, is similar to the audio board. The parts associated with the ladder networks should be close to the given values to obtain the proper bandwidth characteristics. The BFO for the product detector is located on the counter board because its strong field, if mounted on the i-f board, will swamp the AGC circuit.

Testing the i-f board

To check the i-f board, insert it in J2. The audio board should also be plugged in and a speaker connected. Turn on the power and check the voltages against the schematic. Reset the AGC pot (*audio board*) to approximately 5 volts. Connect an antenna of approximately 25′ or longer to pin V of the i-f board. You should hear WWV under nighttime conditions. An adjustment can be made to the trimmer capacitor across the output coil of the MC1350 to give maximum output.

The counter board

Construct the counter board (See fig. **6A, B, C**) next; you'll use it to adjust the oscillator coils to the correct frequency.

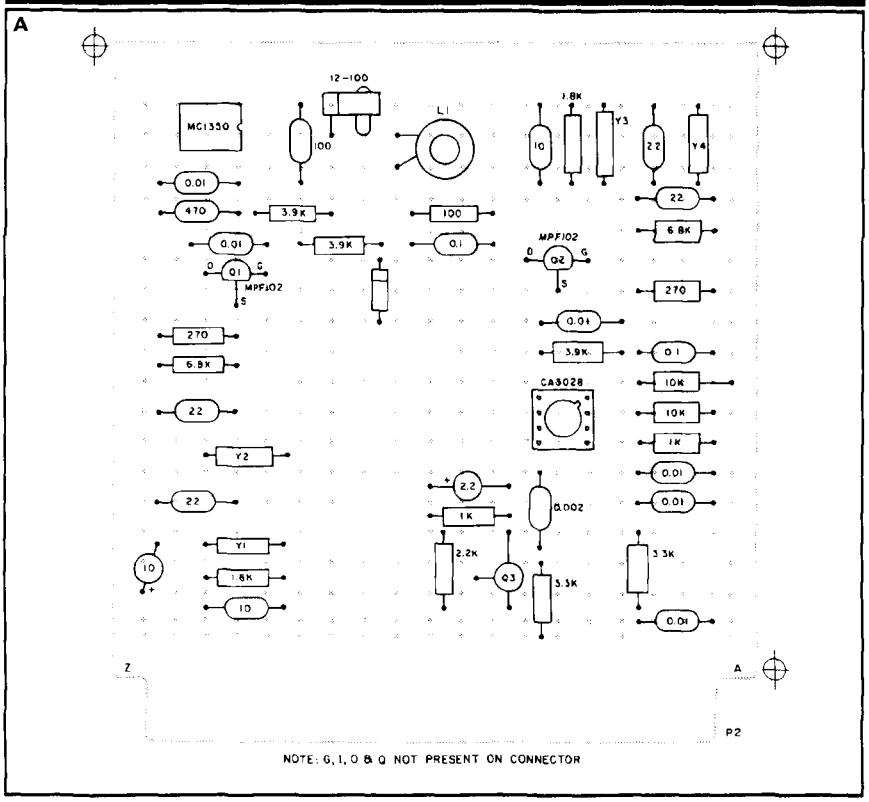
The counter is designed as a multiplexing device — so the display must be designed for multiplexing, or for discrete displays having their common segments tied together. I used a multiplexing type and was able to cut the line to the unwanted decimals, leaving just one for the 100-Hz range. Unless you are familiar with this type of display, I recommend using discrete ones. I used ribbon cable, with its multicolored wires, to aid in wiring the segments.

The counter programming as wired is for 5 MHz, but it can be programmed for other frequencies.[5] The counter clock uses a 3.2678-MHz crystal. ***Figure 6D*** shows a means for shifting its frequency slightly is provided for additional calibration accuracy.

The counter board also contains the 5-MHz BFO circuit for the product detector. It too has a means to shift its frequency a bit to calibrate it with WWV.

To check the counter board, do not insert any IC until you have checked the voltages present on the various IC sockets. Plug the board into socket J3. Be sure that the voltage is 5 volts to prevent any damage to the ICs — in particular the counter, which costs about $10. Remember to turn the power *off* before inserting the ICs.

FIGURE 5



I-F board parts placement guide.

First plug in the oscillator-counter IC (4060). A simple way to see if the circuit is working is to connect the output of the 4060 (pin 3) to pin C of the audio board. You should hear a buzzing sound. The frequency should be 200 Hz. Next plug in the rest of the ICs. If the counter is working, check it by grounding pin P of J3. The range switch should be on the kHz position. The display should read 5000 ± one count if the circuit is working. If it comes up with some unreadable numbers, chances are that there is a wiring error. On the 100-Hz range, the display should go blank.

Now you can check the 5-MHz BFO. Plug in the i-f and audio boards with a speaker connected. Once again, connect an antenna to the i-f board input (pin V). Use WWV, which should be receivable during the evening hours. During voice announcements adjust the capacitor on the circuit to zero beat to WWV. If you can't do this, you may have to try another crystal. When the capacitor is set correctly, the voice on WWV should sound natural.

COMPUTERIZE YOUR SHACK

YAESU 747, 757GX, 757GXII, 767, 9600.
KENWOOD TS 140, 440, 940, 680, R5000.
ICOM R71A, R7000, 735, 751A, 761, 781, AND ALL VHF, UHF, CI-V.
DRIVERS FOR RADIOS ARE MODULAR.
JRC NRD 525.

COMPLETE PROGRAM ENVIRONMENT.
MENU DRIVEN AND DESIGNED FOR EASE OF USE.
SCAN FUNCTION ADDED TO RADIOS THAT DO NOT SUPPORT IT.
ERGONOMETRICALLY DESIGNED FOR EASE OF OPERATION.
MOST FUNCTIONS REQUIRE SINGLE KEYSTROKES.
PROGRAM COLOR CODED FOR EASE OF USE, ALTHOUGH WILL STILL RUN IN A MONOCHROME SYSTEM.

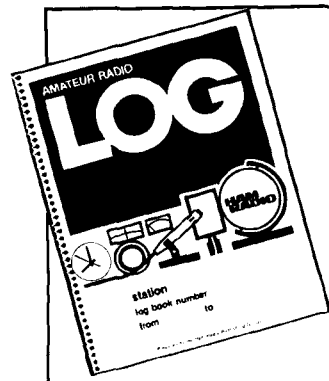
MENUS FOR THE FOLLOWING:
AMATEUR HF—AMATEUR VHF— AMATEUR UHF
AM BROADCAST—FM BROADCAST—TELEVISION BROADCAST
SHORT WAVE BROADCAST
AVIATION HF(SSB)—AVIATION VHF—AVIATION UHF
HIGH SEAS MARINE—VHF MARINE
MISCELLANEOUS HF, VHF, UHF
MOST POPULAR FREQUENCIES ALREADY STORED
ADDITIONAL LIBRARIES AVAILABLE
COMPLETE LOGGING FACILITY
ALL FREQUENCY FILES MAY BE ADDED TO, EDITED OR DELETED

AVAILABLE FOR IBM PC, XT, AT, 80386 256K RAM
1 SERIAL PORT AND 1 FLOPPY MINIMUM

PROGRAM WITH INITIAL LIBRARIES	**99.95**
RS-232 TO TTL INTERFACE ONLY (NEEDED IF DON'T HAVE MANUFACTURERS INTERFACE)	
EXTERNAL INTERFACE ALLOWS 4 RADIOS	**99.95**
INTERNAL PC INTERFACE W/1 SERIAL & 1 RADIO PORT	**129.95**
SPECTRUM ANALYZER MODULE	(CALL FOR PRICE)
COMPLETE SYSTEMS INCL. RADIO, INTERFACE, COMPUTER, AVAILABLE	(CALL FOR PRICE)

DATACOM, INT.
8081 W. 21ST LANE
HIALEAH, FL 33016
AREA CODE (305) 822-6028

187



GREAT HOLIDAY GIFT IDEA

NOW BACK IN STOCK

HAM RADIO LOG BOOKS

back by popular demand!

Room for over 2100 QSO—that's over twice as many as the other log books. For contesters, each page contains 30 QSO's for easy counts. You also get the latest up-to-date frequency spectrum chart. ITU callsign list and ARRL DXCC list. Spiral bound to lay flat on your desk. Unquestionably the best log book value around. © 1988.

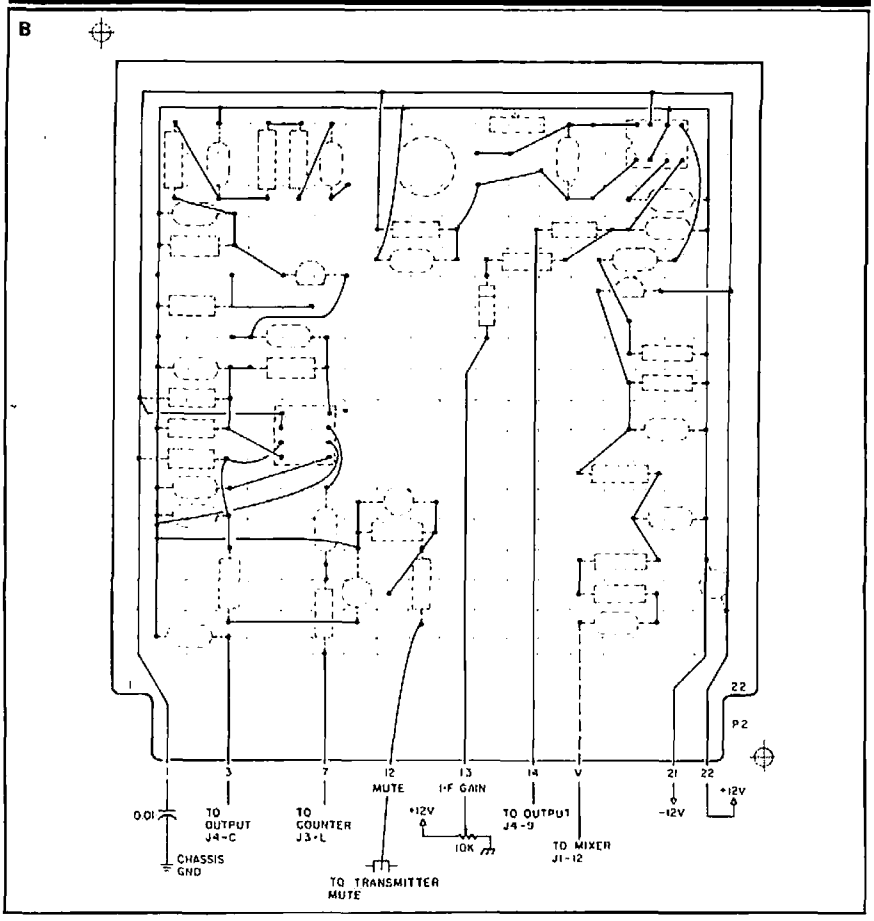
HR-LB.....Spiralbound $2.95
HR-3LB Special
Buy 3 Price. Save 22%.....Get 3 offer $6.95

Please Add $3.50 for shipping and handling.

ham radio magazine BOOKSTORE
GREENVILLE, NH 03048

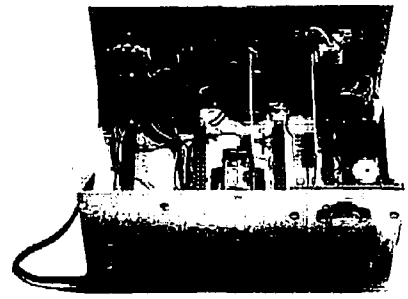
VISA

FIGURE 5



I-F board foil-side connections.

PHOTO A

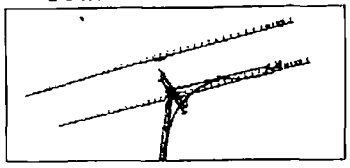


Rear view of receiver

Mixer board

The mixer board in **figs. 7A-C** is next because it has the adjustment pots for setting the oscillator frequencies. They could have been placed on the oscillator board, but my original design had the oscillator on the plug-in board. The stability of the oscillator was very poor, so I put it on a separate board attached directly to the chassis. I didn't have room for the pots, so they remained on the plug-in board. The 9-volt supply is also located on the mixer board. The mixer coil is wound on a T50-6 toroid with 80 turns of no. 30 AWG and ten turns on the primary. The number of turns on the secondary will be adjusted later to give about 10

DOWN EAST MICROWAVE



MICROWAVE ANTENNAS AND EQUIPMENT

• Loop Yagis • Power Dividers • Linear Amplifiers • Complete Arrays • Microwave Transverters • GaAs FET Preamps • TROPO • EME • Weak Signal • OSCAR • 902 • 1269 • 1296 • 2304 • 2400 • 3456 MHz

2345 LY	45el	loop Yagi	1296 MHz	20dBi	$97
1345 LY	45el	loop Yagi	2304 MHz	20dBi	$84
3333 LY	33el	loop Yagi	902 MHz	18.5dBi	$87

Above antennas assembled and tested. Kits available.

Add $6 UPS S/H, $11 West of the Mississippi

MICROWAVE LINEAR AMPLIFIERS SSB, ATV, REPEATER, OSCAR

2316 PA	1w in 16w out	1240-1300 MHz	13.8V	$255
2335 PA	10w in 35w out	1240-1300 MHz	13.8V	$305
3318 PA	1w in 20w out	900-930 MHz	13.8V	$255
3335 PA	18w in 40w out	900-930 MHz	13.8V	$305
23LNA preamp 0.7dB N.F.		1298 MHz		$ 80
33LNA preamp 0.9dB N.F.		902 MHz		$ 80

Add $5 shipping UPS/48

LMW 1296 & 2304 MHz transverter kits in stock

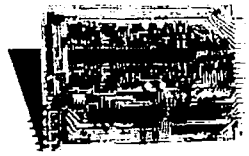
Write for free catalog

VISA

DOWN EAST MICROWAVE
Bill Olson, W3HQT
Box 2310, RR 1, Troy, ME 04987
(207) 948-3741

184

THE MULTIPLE RECEIVER SOLUTION



4 Channel Signal-to-Noise Voter

- Expandable to 32 Channel by Just Adding Cards
- Continuous Voting
- LED Indicators of COR and Voted Signals
- Built-in Calibrator
- Remote Voted Indicators Pinned Out
- 4½ x 6 Double Sided Gold Plated 44 Pin Card
- Remote Disable Inputs
- MORE

Built, tested and calibrated with manual

$350.00

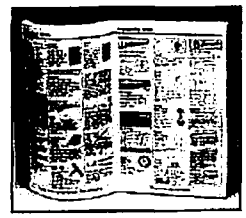
Telephone interface now available
For more information call or write:

DOUG HALL ELECTRONICS
Voter Department
815 E. Hudson Street
Columbus, Ohio 43211
(614) 261-8871

185

FREE CATALOG!

Features Hard-to-Find Tools and Test Equipment



Jensen's new catalog features hard-to-find precision tools, tool kits, tool cases and test equipment used by ham radio operators, hobbyists, scientists, engineers, laboratories and government agencies. Call or write for your free copy today.

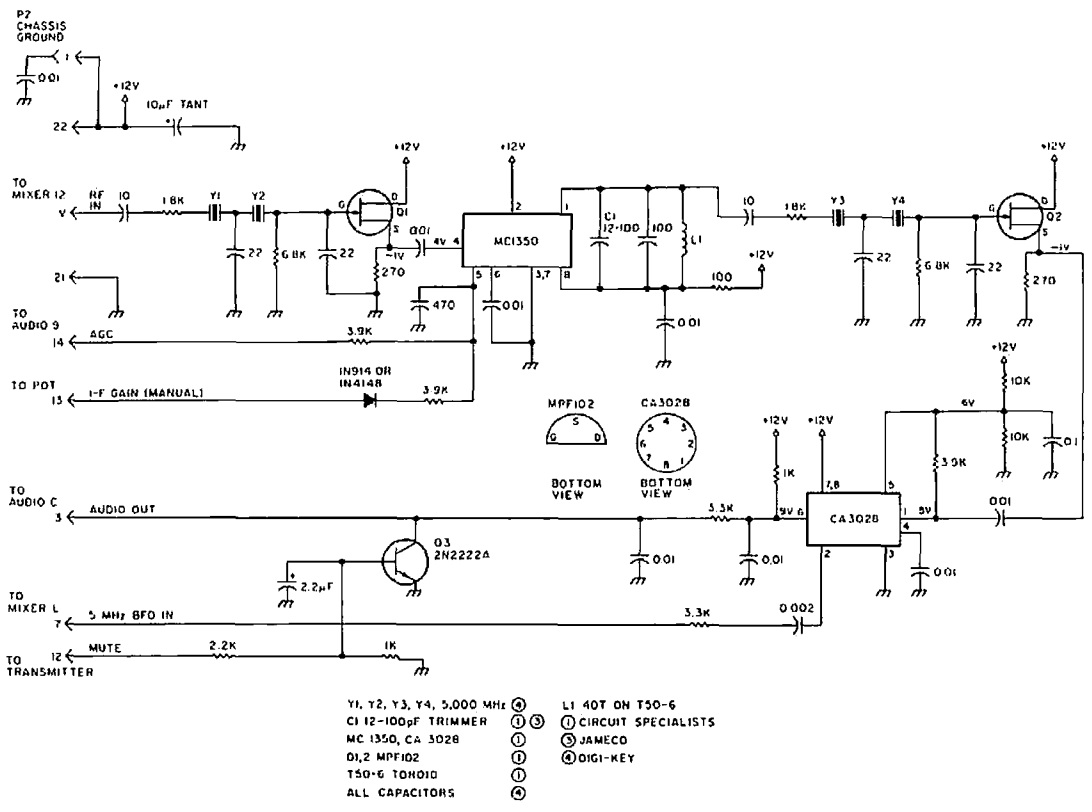
JENSEN TOOLS INC.

Dept. HR
7815 S. 46th Street
Phoenix, AZ. 85044
(602) 968-6231

186

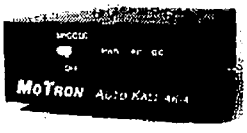
FIGURE 5

C



I-F board schematic.

Six Function DTMF Controller



Auto-Kall AK-4

- Outputs 2 or 3 latched, 1 or 2 momentary, 1 timed and 1 manually reset group-call latched for remote alarm
- Different codes for turning outputs on/off NOT toggle on/off like most others! • Wrong number reset
- 4-digit acess code - can use * up # down
- Multiple group-call response • On-board 1-amp relay

AK-4K (board/kit) $69.95
AK-4W (wired/tested board) . . $89.95
AK-4C (Complete unit in metal enclosure with in/out jacks, built in speaker, etc.) $139.95
Plus $3.00 shipping & handling

MoTron Electronics
695 W. 21st Ave.
Eugene, OR 97405
Call Toll Free **1-800-338-9058** or (503) 687-2118

183

"NEW" SUPER LINEAR ANTENNA SYSTEM

MODEL	FREQUENCY	GAIN	POWER	LENGTH	USE	PRICE
CA-2x4z	146 MHZ 446 MHZ	8.2dB 11.5dB	200 W	15'4"	Base	$192.85
CA-1243E	446 MHZ 1.2GHZ	8.5dB 10.1dB	100 W	4'8"	Base	$ 85.95
CA-901	146/446/1.26GHZ	3/6/8.4dB	150 W	3'5"	Base	$ 91.55
CFC-771	900-930MHZ	7.14dB	50 W	4'5"	Base	$ 97.40
CA-1221S	1260/1300	15.5dB	100 W	7'8"	Base	$151.90
CA-2422S	2400/2450	15.3dB	100 W	4'8"	Base	$173.55

NEW! SWR Power Minimeters

CM 200 —	144 - 150 MHZ	$ 62.50
CM 300 —	200 - 230 MHZ	$ 62.50
CM 400 —	420 - 460 MHZ	$ 62.50
CM 900 —	900 - 930 MHZ	$ 93.50
CM 1200 —	1200 - 1300 MHZ	$ 93.50

DUAL & TRI BAND MOBILE ANTENNA'S DUPLEXERS - TRI PLEXERS
Dealer inquiries welcomes.

(714) 630-4541
1275 N. Grove St., Anaheim, CA 92806

Specifications and prices subject to change without notice or obligation.

182

1989 CALLBOOKS



THE QSL BOOK!

Continuing a 68 year tradition, we bring you three new Callbooks for 1989, bigger and better than ever!

The North American Callbook lists the calls, names, and address information for 495,000 licensed radio amateurs in all countries of North America, from Canada to Panama including Greenland, Bermuda, and the Caribbean islands plus Hawaii and the U.S. possessions.

The International Callbook lists 500,000 licensed radio amateurs in countries outside North America. Its coverage includes South America, Europe, Africa, Asia, and the Pacific area (exclusive of Hawaii and the U.S. possessions).

The 1989 Callbook Supplement is a new idea in Callbook updates, listing the activity in both the North American and International Callbooks. Published June 1, 1989, this combined Supplement will include thousands of new licenses, address changes, and call sign changes for the preceding 6 months.

Every active amateur needs the Callbook! The 1989 Callbooks will be published December 1, 1988. Order early to avoid disappointment (last year's Callbooks sold out). See your dealer now or order directly from the publisher.

☐ North American Callbook
incl. shipping within USA $29.00
incl. shipping to foreign countries 35.00

☐ International Callbook
incl. shipping within USA $32.00
incl. shipping to foreign countries 38.00

☐ Callbook Supplement, published June 1st
incl. shipping within USA $13.00
incl. shipping to foreign countries 14.00

SPECIAL OFFER

☐ Both N.A. & International Callbooks
incl. shipping within USA $58.00
incl. shipping to foreign countries 68.00

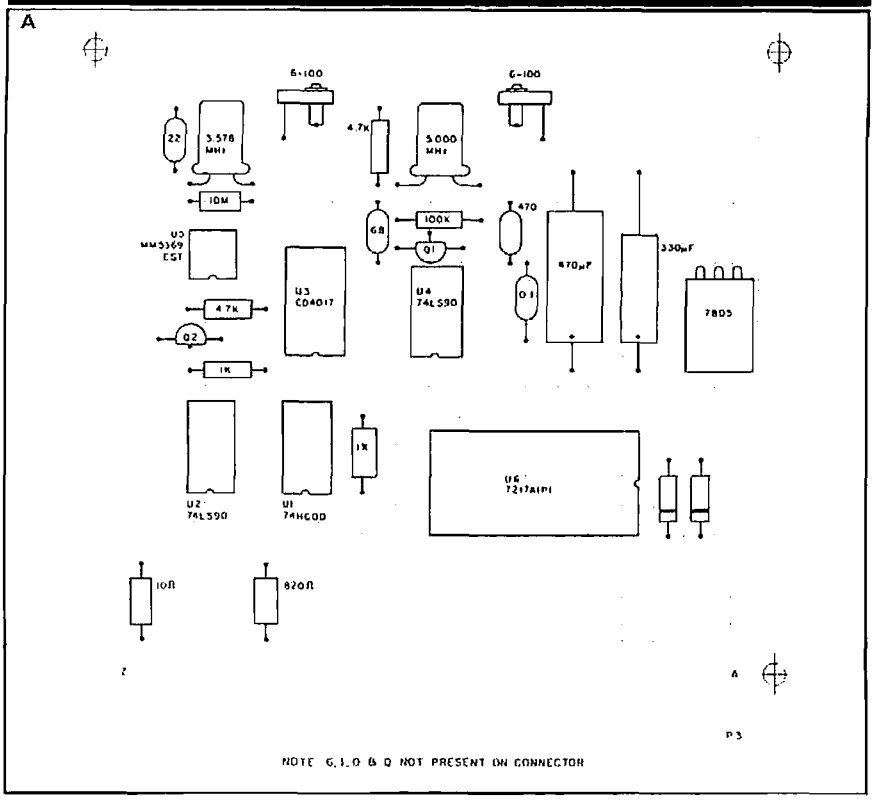
* * * * * * * * * * * *

Illinois residents please add 6½% tax.
All payments must be in U.S. funds.

RADIO AMATEUR **callbook** INC.
Dept. F
925 Sherwood Dr., Box 247
Lake Bluff, IL 60044, USA

Tel: (312) 234-6600 VISA MasterCard

FIGURE 6



Counter board parts placement guide.

percent of the value of the 360-pF variable for peaking the 40-meter band. Experiment to find the 160-meter switched-in capacitor. I used a 550-pF capacitor, but a lot depends on other circuit capacitances. You'll have to retune the mixer capacitor as you go across the 160 and 80/75 bands, but this greatly simplifies the circuitry.

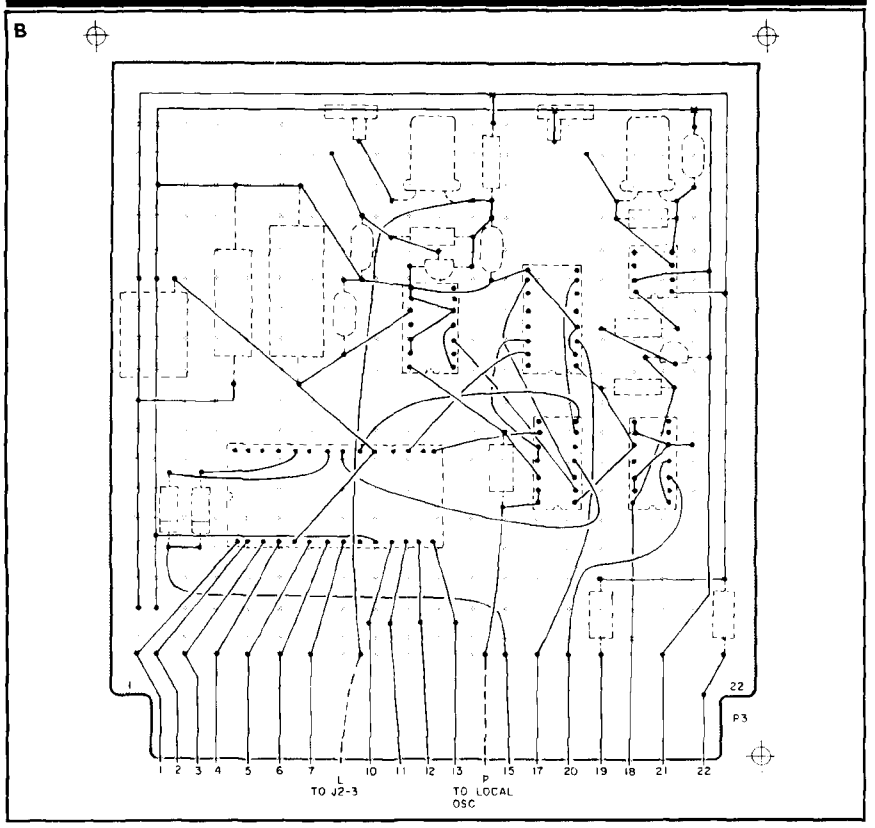
When the board is completed, check it out by plugging it in J1. The rest of the boards should also be in. Short out the WWV trap by closing the switch across the trap coil. Connect an antenna to the input jack. With power on, you should hear WWV with the mixer-tuning capacitance set about 40 percent. (Of course this should be done during nighttime conditions when WWV comes in best.) The receiver may oscillate at this point because there are three stages tuned to the same frequency. Just detune the mixer capacitance a small amount. Some of this oscillation will be reduced when a shield is placed between J1 and J2. A shield will also be placed between J2 and J3. Please note that there is a capacitor between pin 1 and chassis ground on both J1 and J2. I found these caps helped reduce the multiplexing noise from the counter board.

You can also check the effectiveness of the trap at this time. Open the trap switch and tune the capacitance across the coil for minimum signal. If you have successfully completed this board, the next board is the last — you're almost there!

Oscillator board

The board (see **fig. 8A, B, C**) consists of a conventional Colpitts oscillator and buffer with the three oscillator coils for 160, 80/75, and 40 meters tuned by a varicap and a ten-turn pot. The upper end of each band is adjusted by trimmers located on the mixer board. The lower end is done by adjusting the num-

FIGURE 6



Counter board foil-side connections.

ber of turns on the coils. It sounds like a tedious task, but you can perform it rapidly if you use a counter.

The board used for the oscillator is a Radio Shack (no. 276-148). It's mounted to the bottom plate with four stand-offs. The same type of construction is used as on the plug-in boards. Because of the limited space, the toroids are mounted vertically. I used polystyrene capacitors for temperature stability but they may be hard to find. Use, in place, any capacitor that has a low temperature coefficient.

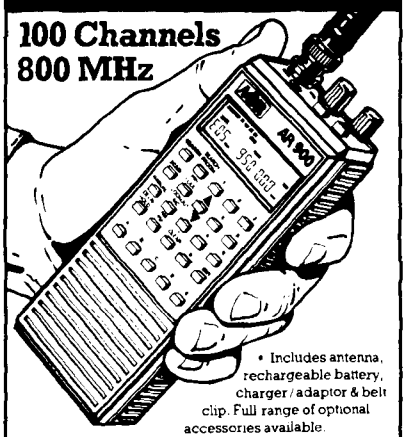
When the board is wired and checked, mount it to the bottom plate and connect the band switch and ten-turn pot. Set the band switch to 160 meters. With all boards in and the power on, the counter should indicate a frequency somewhere between 1.5 and 2.5 MHz. Turn the tuning dial; the frequency should change. Turn the dial to give the highest reading. Adjust the trim resistor on the mixer board designated 160 M trim. Adjust it in a direction towards 2.0 MHz. Turn the dial to the other end and add or remove turns until the counter approaches 1.8 MHz. Repeat the process until adjustments give 1.795 and 2.005 MHz. Final adjustments can be made by spreading the turns. Repeat the same process for 80 and 40. The 75-meter band has two adjustments. Set the upper to 4.005 and the lower at 3.790 MHz. I have set the 80-meter band to cover 3.600 to 3.805.

Final adjustments

With the oscillator working, it's time to connect the receiver to an antenna. During the day, the best band to try is 40 meters. Set the band switch to 40 M. Be sure the mixer capacitor for 160 is out of the circuit. Adjust the mixer capacitor to about 10 percent of full scale. You should hear an increase in background noise. Signals should be audible, and the display should indicate the right frequency.

New Scanner by AOR

100 Channels 800 MHz

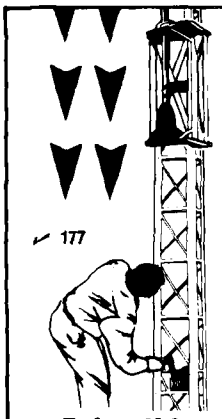


• Includes antenna, rechargeable battery, charger/adaptor & belt clip. Full range of optional accessories available.
• Covers 27-54 MHz, 108-174 MHz, 406-512 MHz, and 800-950 MHz.
• 5 Scan Banks and 5 Search Banks.
• 25 Day Satisfaction Guarantee. Full Refund if not Satisfied.
• No Frequencies cut out.
• Size: 2" x 5¾" x 1½" wt: 12 oz.

AR900
Total Price. Freight Prepaid (Express Shipping Optional)
$299.00

MCE COMMUNICATIONS
10707 E. 106th St. Indpls., IN 46256
Toll Free **800-445-7717**
Visa and MasterCard
(COD slightly higher)
In Indiana 317-849-2570 Collect FAX (317) 849-8794

176



177

SAVE TIME and MONEY with THE HAZER

Bring things down for safety and convenience.

Never climb your tower again with this elevator system. Antennas and rotator mount on HAZER, complete system trams tower in vertical upright position. Safety lock system operates while raising or lowering. Never can fall.

Complete kit includes winch, 100 ft. of cable, hardware and instructions. For Rohn 20 and 25 G Towers.

Hazer 2-Heavy duty alum. 12 sq. ft. load	$311.95 ppd.
Hazer 3-Standard alum. 8 sq. ft. load	$223.95 ppd.
Hazer 4-Heavy galv. steel 16 sq. ft. load	$291.95 ppd.

NEW for ROHN 45 and 55 Towers

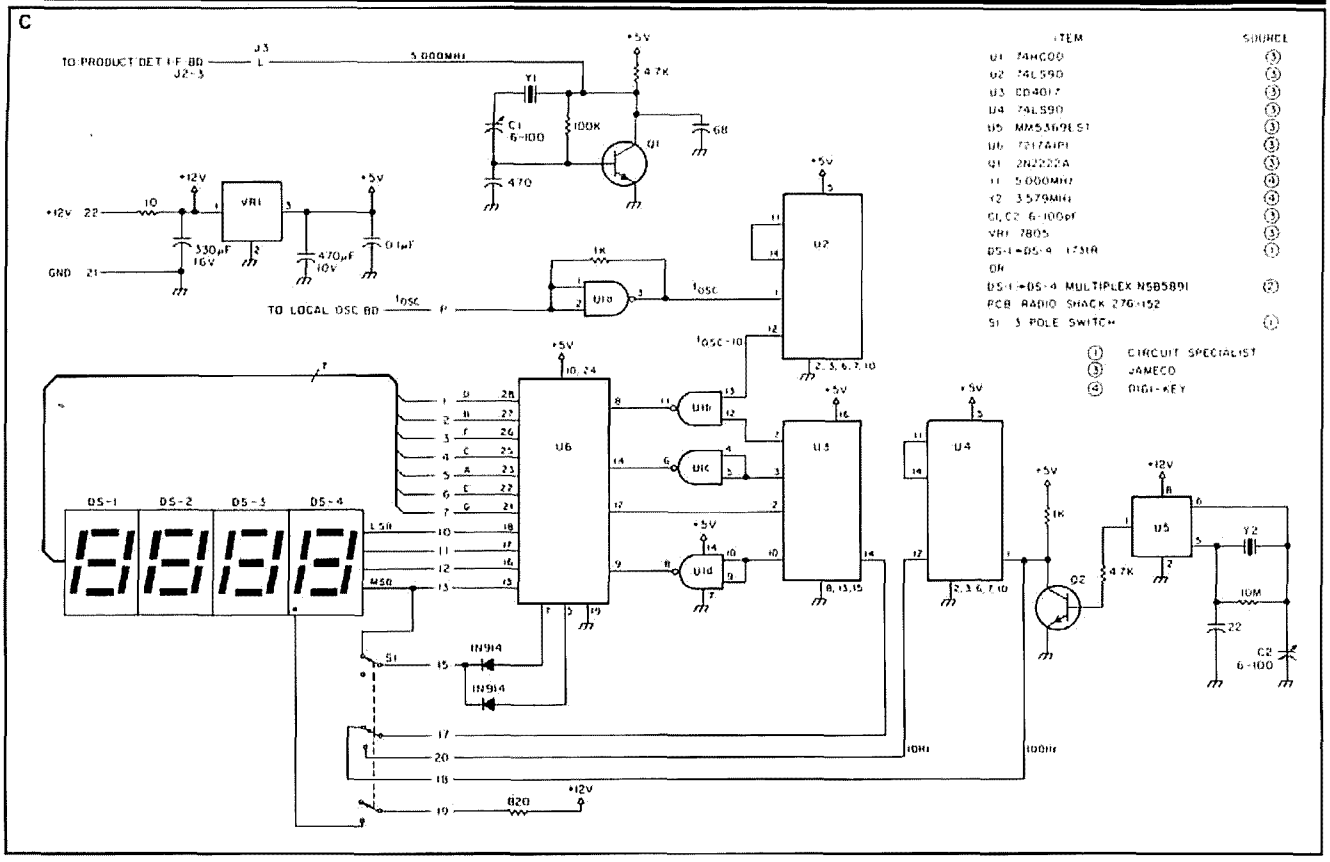
Hazer 8-Heavy duty galv. steel 16 sq. ft. load	CALL
Ball Thrust Bearing TB-25 for any of above	Call for price

Send for free details of aluminum towers specifically engineered for use with the Hazer. Two sizes: M-18 (13" wide) and M-18 (18" wide). All bolted construction, no welds. Easy to install hinge base, walk up erection. Complete tower UPS or air freight shippable. Pre-assembled or kit form.

Satisfaction guaranteed. Call today and charge to Visa, MasterCard or mail check or money order.

GLEN MARTIN ENGINEERING INC.
Rte 3, Box 322
Boonville, MO 65233
(816) 882-2734 FAX 816-882-7200

FIGURE 6



Counter board schematic.

Editor's Note: As the November issue was going to press, Jim found out that Radio Shack has discontinued pc board no. 276-152. He has redesigned the printed circuit assemblies to fit Radio Shack's board no. 276-154. Jim will be happy to send copies of the new drawings to anyone who sends him one dollar in stamps to cover the cost of printing and postage.



R-7000 Widespan Panadaptor

Panadaptor especially designed for the R-7000 receiver. For use with a standard scope. Variable span width from 1 to 10 Mhz. Uncover unknown elusive signals. Complete with all cables, & 90 day warranty. $349.95 Shipped. Pa. res. add 6%.

GTI Electronics
RD 1 BOX 272
Lehighton, Pa. 18235
717-386-4032

174

pauldon ASSOCIATES

Microwave	UHF
1.2 Ghz. power amplifiers brick modules	900 Mhz. FM power amplifiers Linear power amplifiers Class "C" brick modules Linear brick modules
1.2 Ghz. preamplifier	400 Mhz. Linear power amplifiers Linear brick modules
VHF	900 Mhz. Preamps.
220 Mhz. Pre-amps.	440 Mhz. Preamps.
144 Mhz. Pre-amps.	Transistors

Nec.	2SK-571 C2558	Mrf- 1402 1302	Mgf-1200 1100
Nec.	41137	966	

900 Mhz. FM TRANSMITTERS
ANTENNA SWITCH BOXES
FM TRANSCEIVERS

Tel. 1-716-692-5451 W2WHK
210 Utica St. Tonawanda, NY 14150

Discover CAROLINA WINDOM

80-10 M
Use Transmatch
132' overall
Matching XFMR
Line Isolator
Vert Radiator
Coax fed
Assembled
$69.96

High performance
Proven results
$70 Beam?

The RADIO WORKS

Your Passport To a world Of new ideas And exceptional HF wire antennas

Rugged new baluns
Full range of HF, UHF, mobile antennas, ducks, wire, coax, parts, line, accessories.

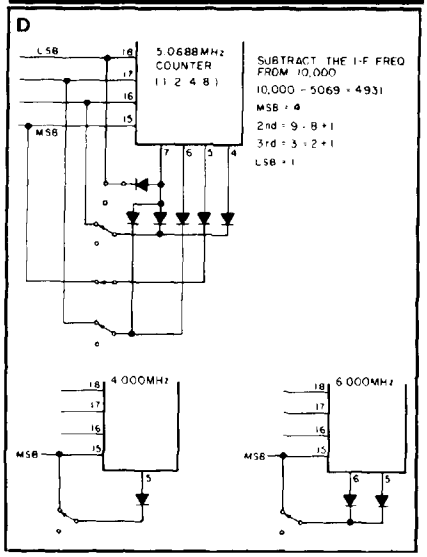
SEE WHAT WE'RE DOING NOW!
Contact Jim, W4THU
- free discount catalog
Send $1 for catalog by 1st Class mail, Box 6159, Portsmouth, VA 23703
(Dealer inquiries welcome)

804-484-0140

CAROLINA WINDOM
SEE THE REVIEW IN JUNE '88 WORLD RADIO MAGAZINE. Enthusiastic users say it's the best wire antenna. Outperforms wire antennas previously used. Knock-your-socks-off performance on 80 - 10. A $70 beam?
If you hear one, you'll want one.
Made with pride by The RADIO WORKS in VA/USA

175

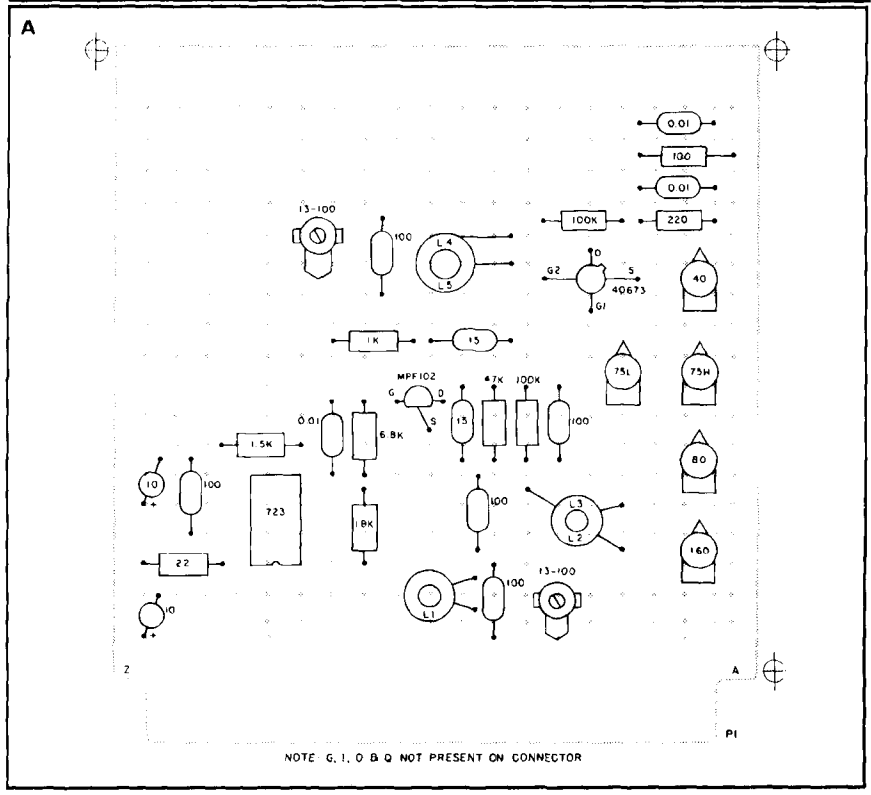
FIGURE 6



Detail for slightly changing the counter to 4 MHz and 6 MHz.

Before making any further adjustments to the receiver, add the shields between J1 and J2, and J2 and J3. The shield on the side of the oscillator should also be in place. This shield prevents the oscillator frequency from shifting when

FIGURE 7



Mixer board parts placement guide.

QRZ CONTEST!™

VHF Contest Software
for PC Compatibles
$39.95 postage paid

- Covers all VHF and UHF contests
- Includes the 70 MHz European band
- Menu driven and user friendly
- Color and options user configured
- Grids worked display on-line!
- Full dupe checking
- Complete log editor included
- Handles 4000 contacts with 512K
- Demo-version available $5.00
- \+ HF Version to be available soon!

ATFAB Computers and Electronics

P.O. Box 4766
Maineville, OH 45039
(513) 683-2042

Accepted

171

NEMAL ELECTRONICS

***Complete Cable Assembly facilities MIL-STD-45208**
***Commercial Accounts welcome- Quantity pricing * Same day shipping most orders**
***Factory authorized distributor for Alpha, Amphenol, Belden, Kings, Times Fiber**

Call NEMAL for computer cable, CATV cable, Flat cable, semi-rigid cable, telephone cable, crimping tools, D-sub connectors, heat shrink, cable ties, high voltage connectors.

HARDLINE 50 OHM

FXA12 1/2" Aluminum Black Jacket	.89/ft
FLC12 1/2" Cablewave corr. copper blk jkt	1.69/ft
FLC78 7/8" Cablewave corr.copper blk jkt	3.92/ft
NM12CC N conn 1/2" corr copper m/f	25.00
NM78CC N conn 7/8" corr copper. m/f	54.00

COAXIAL CABLES *(per ft)*

1180 BELDEN 9913 very low loss	.52
1102 RG8/U 95% shield low loss foam 11ga	.36
1110 RG8X 95% shield (mini 8)	.17
1130 RG213/U 95% shield mil spec NCV jkt	.39
1140 RG214/U dbl silver shld mil spec	1.85
1705 RG142B/U dbl silver. shld, teflon ins	1.50
1310 RG217/U 50 ohm 5000 watt dbl shld	.98
1450 RG174/U 50 ohm .100" od mil spec	.14

ROTOR CABLE-8 CONDUCTOR

8C1822 2-18ga and 6-22ga	.21
8C1620 2-16ga and 6-20ga	.39

CONNECTORS-MADE IN USA

NE720 Type N plug for Belden 9913	$3.95
NE723 Type N jack for Belden 9013	4.96
PL259 standard UHF plug for RG8,213	.65
PL259AM Amphenol PL259	.89
PL259TS PL259 teflon ins/silver plated	1.59
PL258AM Amphenol female-female (barrel)	1.65
UG175/UG176 reducer for RG58/59 (specify)	.22
UG21DS N plug for RG8,213,214 Silver	3.35
UG83B N jack to PL259 adapter, teflon	6.50
UG146A SO239 to N plug adapter, teflon	6.50
UG255 SO239 to BNC plug adapter, Amphenol	3.29
SO239AM UHF chassis mt receptacle,Amphenol	.88

GROUND STRAP-GROUND WIRE *(per ft.)*

GS38 3/8" tinned copper braid	.40
GS12 1/2" tinned copper. braid	.50
GS200 1-1/2" heavy tinned copper braid	2.00
HW06 6ga insulated stranded wire	.35
AW14 14ga stranded Antenna wire CCS	.14

Prices do not include shipping, $3 minimum, Visa/Mastercard $30 min, COD add $3.00
Call or write for complete price list. Nemal's new 36 page CABLE AND CONNECTOR SELECTION GUIDE is available at no charge with orders of $50 or more, or at a cost of $4 with credit against next qualifying order.

NEMAL ELECTRONICS, INC. 12240 NE 14th Ave. N. Miami, FL 33161
(305) 893-3924 Telex 6975377 24hr FAX (305)895-8178

GORDON WEST'S
RADIO SCHOOL

21 DAY NOVICE



2 code tapes
112 page book
World maps
Frequency charts
Course certificate
Free magazine coupon
50 piece literature set!

$70 in equipment certificates from ICOM, KENWOOD, and YAESU $19.95

COMPLETE NOVICE COURSE $49.95
4 code tapes, 2 theory tapes, 2 text books, code oscillator set, examiner test packet, and $70 discount coupons.
NOVICE TEXTBOOK $4.95
Written by Gordon West, this 112 page book contains all Novice questions and answers.
NOVICE CODE COURSE $39.95
6 tape stereo code course for learning the code from scratch. Includes certificates
TECHNICIAN THEORY COURSE $19.95
2 theory tapes & 2 textbooks.
GENERAL THEORY COURSE $19.95
2 theory tapes & 2 textbooks.
TECHNICIAN/GENERAL COURSE $19.95
Combined tech & general course with 4 tapes and 1 book.
THE COMPLETE GENERAL $49.95
4 tapes & 2 books for theory plus 6 tape stereo code set for CW speed building.
GENERAL CODE COURSE $39.95
6 tape stereo code course for CW speed building from 5 wpm to 13 wpm.
THE COMPLETE ADVANCED $49.95
4 tapes & 2 books for theory plus 6 tape stereo general or extra class code course. (Specify which CW tapes you want.)
ADVANCED THEORY CLASS $19.95
4 tape stereo theory course plus fully illustrated theory book.
THE COMPLETE EXTRA $49.95
4 tapes & 2 books for theory plus 6 tape stereo code set for CW speed building 13 wpm to 22 wpm+!
EXTRA CODE COURSE $39.95
6 tape stereo code course for CW speed building from 13 wpm to 22 wpm+.
EXTRA THEORY CLASS $19.95
4 tape stereo theory plus fully illustrated theory book.
GORDON WEST ELECTRONICS BOOK
200 page marine electronics book plus marine mobile antenna hints. $19.95
COMMERCIAL TEST PREP BOOK $29.95
BRASS CODE KEY & OSCILLATOR $19.95
PLASTIC CODE KEY & OSCILLATOR $14.95
COPPER GROUND FOIL 60¢ FOOT

SINGLE CODE TAPES
$9.95 EACH • BUY 2, GET 3rd ONE FREE
• 5 wpm Novice Tests • 5 wpm Random Code
• 5-7 Speed Build • 7-10 Speed Build • 10 Hump Jump
• 10-12 Speed Build • 12-15 Calls & Numbers
• 13 Random • 13 Test Prep • 5-15 General Quiz
• 13 Car Code • 13-15 Speed Build • 15-17 Speed Build
• 17-19 Speed Build • 20 Random • 20 Test Prep
• 20 Car Code • 10-24 Extra Quiz

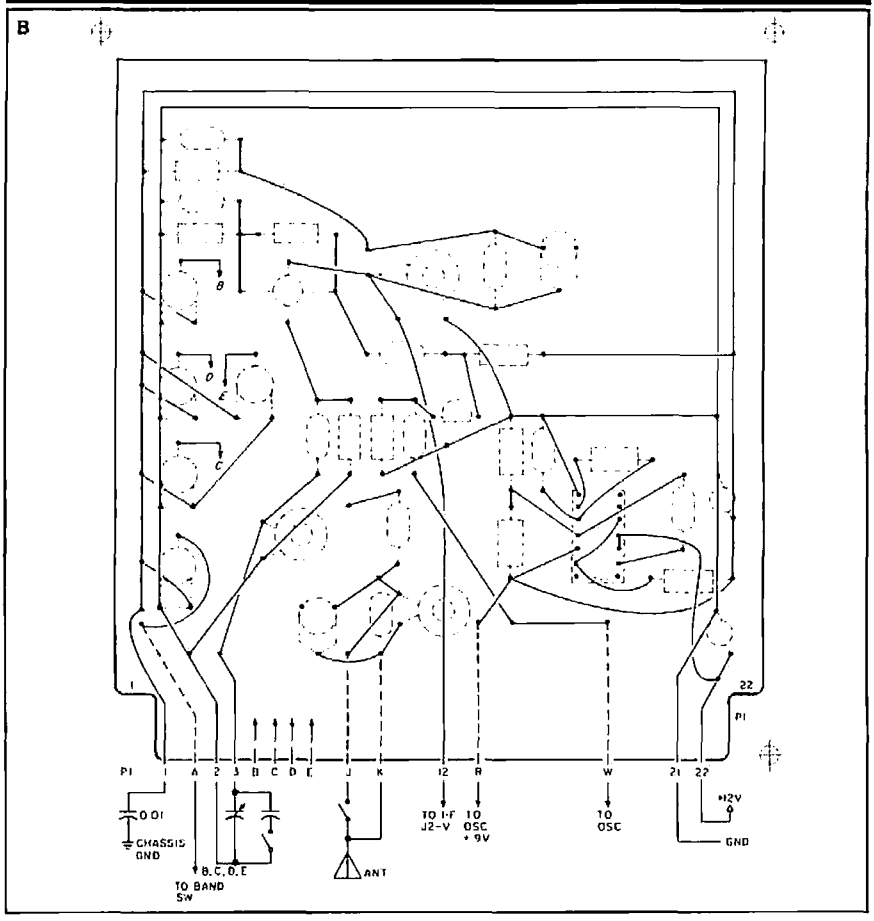
Pass any upgrade & receive $25 Kenwood rebate
** plus a license holder & wall certificate FREE! **

Slow code uses 13 wpm character speed. Same day service. Add $3.00 UPS for courses, or $1.00 for single tapes. 100% return policy.

GORDON WEST RADIO SCHOOL
2414 COLLEGE DR., COSTA MESA, CA 92626
Mon.-Fri. 10-4pm (714) 549-5000

✓ 170

FIGURE 7



Mixer board foil-side connections.

the unit is enclosed in a cabinet. When the shields are in place, make the following adjustments:

1. Set the AGC bias voltage.

Turn the i-f gain pot to minimum voltage. Measure the voltage on pin 5 of the MC1350. The voltage should be set to 5.0 volts using the bias adjust pot on the output board.

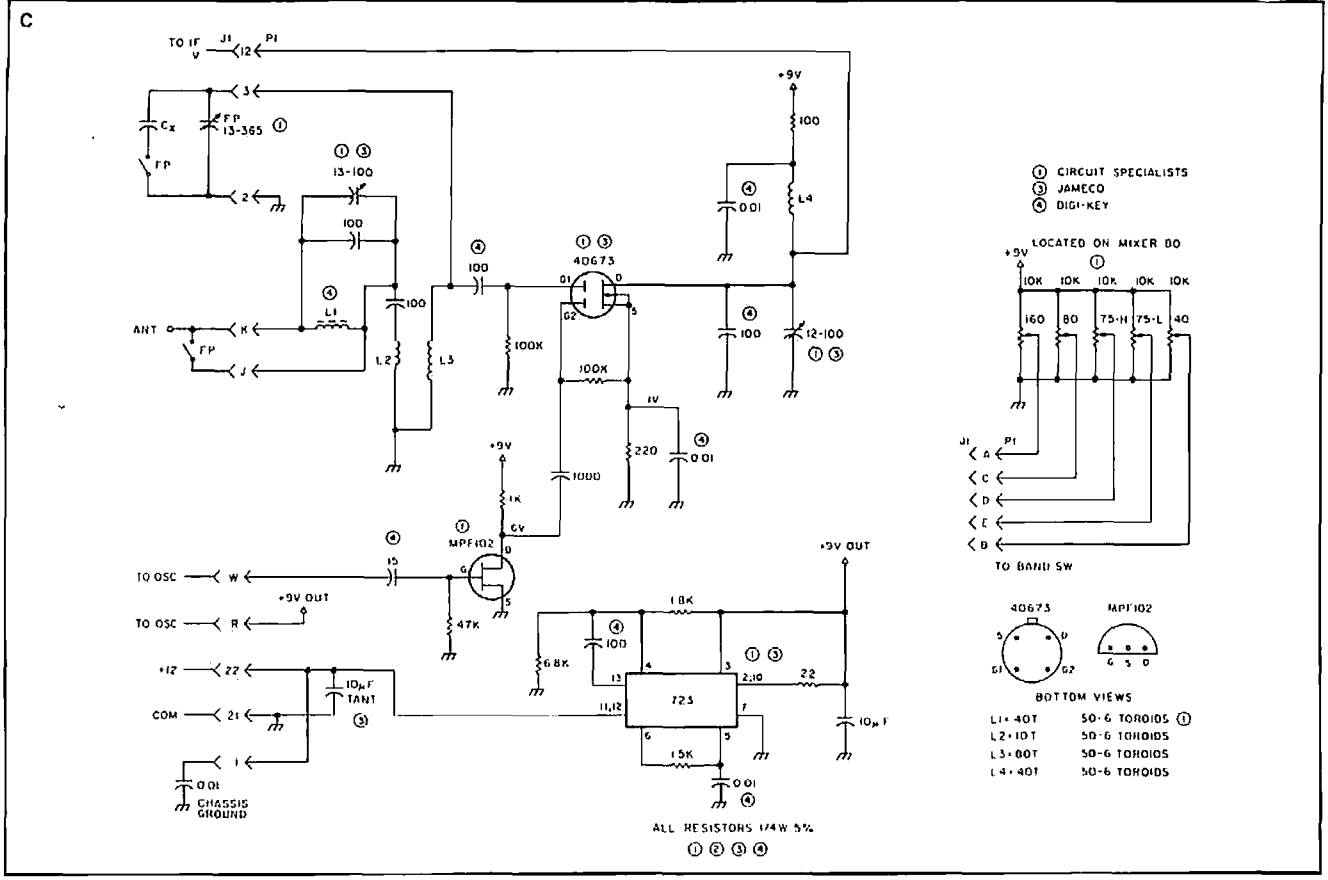
2. Adjust the mixer coil.

Set the receiver to the 40-meter band. With an antenna connected, adjust the turns on the mixer coil so the mixer capacitor peaks at about 10 percent of full scale. Switch to the 80-meter band and check the mixer capacitor setting. It should be about 60 percent of full scale. Repeat the operation for the 160-meter band. Clip lead a 470-pF capacitor across the mixer capacitor. Set the tuning dial to read 1.900 MHz. Vary the mixer capacitor until a peaking in background noise is heard. If the trim capacitor is of the correct value, the mixer capacitor will be about mid-scale. It should read about 90 percent at 1.800 MHz.

3. Set the WWV trap.

If you have been doing some checks in the evening, you have undoubtedly heard WWV in the background. If you have, either the WWV switch is in the shorting position or the trap needs further adjustment. Set the band switch to 40 M and the mixer capacitor to about 30 percent scale. Adjust the trap capacitor to give minimum feedthrough. The 5.000-MHz BFO setting can be rechecked at this time. Wait until the steady tone is off, then adjust the BFO trimmer on the counter board to zero beat with WWV.

FIGURE 7



Mixer board schematic.

4. Mixer and i-f output capacitor adjustments.

With the receiver set on any frequency where there is noise only, adjust each of these capacitors to give maximum output.

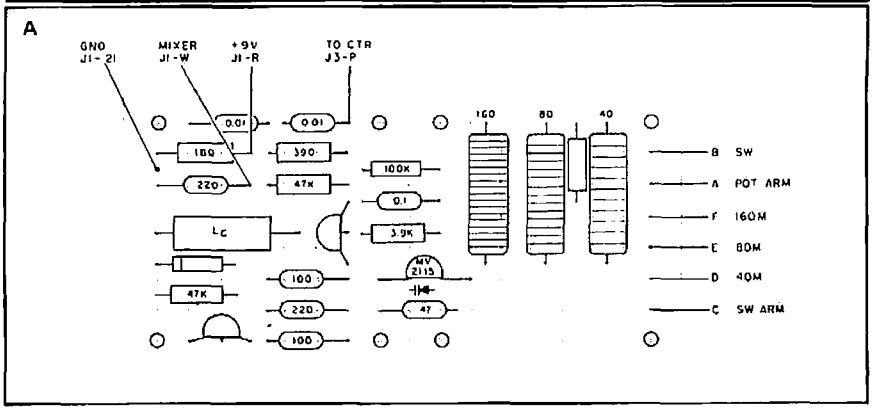
5. Testing the peak-null circuit.

Tune in a steady carrier set to an audio tone of about 1 kHz. Switch on the peaking switch, and rotate the peaking pot until a pronounced increase in signal is present. Now rotate the null pot until the signal is reduced in amplitude. If these actions are noted, these circuits are operating correctly.

6. Final calibration.

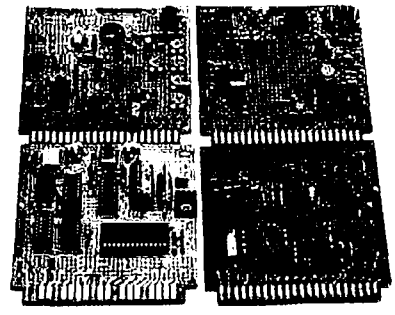
Tune the receiver to 2.000 MHz. A weak signal will be heard that is a subharmonic of 5.000 MHz. Tune the

FIGURE 8



Oscillator board parts placement guide.

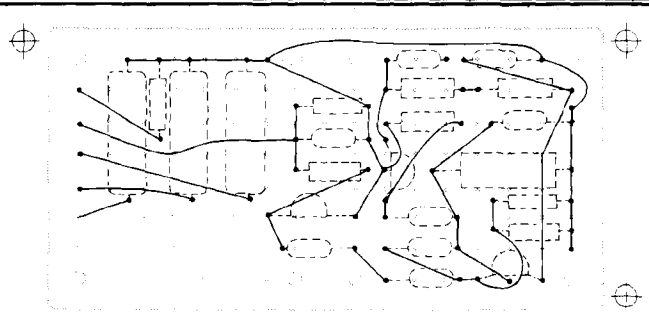
PHOTO B



Upper left, mixer; upper right i-f; lower left, counter; and lower right, audio.

FIGURE 8

B



Oscillator board foil-side connections.

problems, I'll indicate what has to be done to correct the fault. Go to it!

Acknowledgments

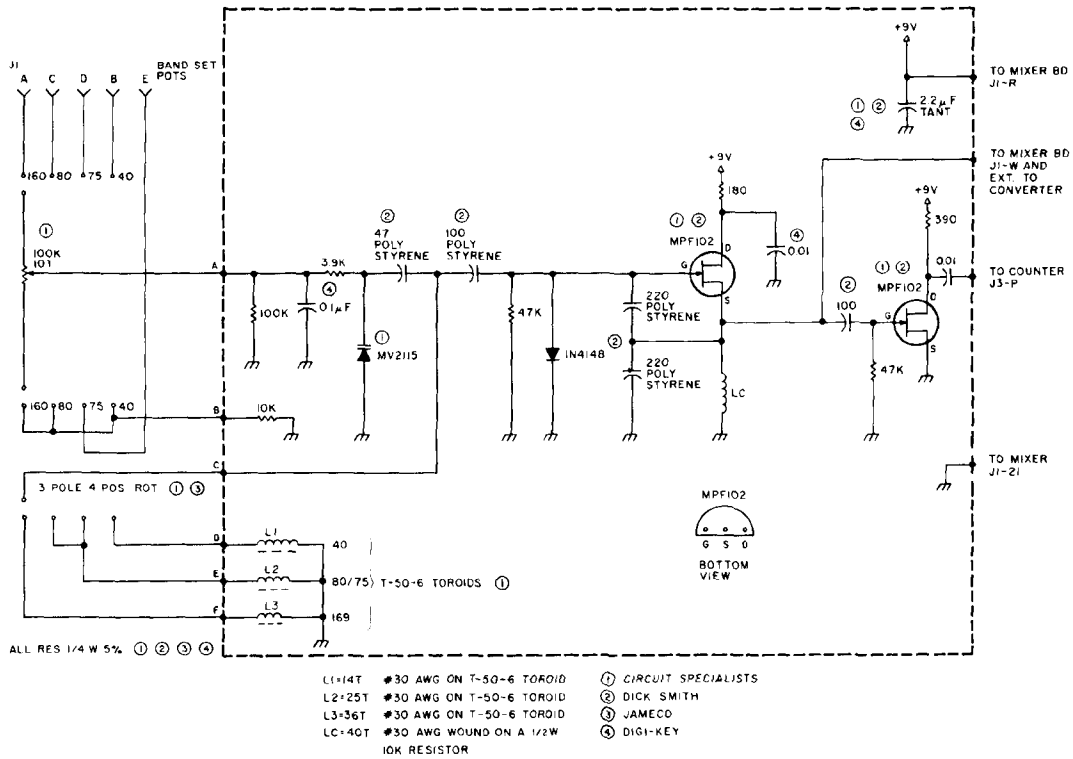
Thanks Francisco Moreno, a photo enthusiast, for taking and enlarging the photos, and to Tom Fattaruso for acting as a sounding board for some of my ideas and coming up with helpful solutions.

Note:

The photo showing the printed circuit assembly of the counter board has been changed slightly to use a different crystal frequency than the original circuit.

FIGURE 8

C



Oscillator board schematic.

receiver to zero beat. Then adjust the counter-oscillator trimmer so the counter reads 2.000 MHz.

Conclusion

Although this receiver is not a single weekend project, each board can be constructed in a weekend. It's a far cry from the first superhet I built before WW II using Miller coils. I've made a number since, but this one outperforms them all. In the future, I'm going to build converters to cover the 20, 15, and a portion of the 10-meter band.

If you have any problem with any of the boards and you've followed the same pin connections that I've used, I will gladly troubleshoot your board for a small fee of $5 per board (postage prepaid). If you've only made a small error, I'll make the correction. On major

References

1. J.A. Hardcastle, G3JIR, "Ladder Crystal Filter Design," *QST*, November 1980.
2. J.A. Hardcastle, G3JIR, "Some Experiments With High Frequency Ladder Crystal Filters," *QST*, December 1978.
3. Wes Hayward, W7ZOI, "A Unified Approach to the Design of Crystal Ladder Filters," *QST*, May 1982.
4. Jim Pepper, W6QIF, "The Magic Filter," *73*, November 1983.
5. Gary Mclellan, "Tune Your Receiver by the Numbers," *Popular Electronics*, October 1981.

Article D **HAM RADIO**

THE WEEKENDER



A 1296-MHz LOW NOISE AMPLIFIER

By Norman J. Foot, WA9HUV, 293 East Madison Avenue, Elmhurst, Illinois 60126

The noise figure of an RF amplifier can be elusive, especially at VHF and above. This is true unless you are fortunate enough to have sophisticated (and very expensive) test equipment at your disposal.

Specifications

Transistors are ordinarily specified by the manufacturer in terms of their scattering S parameters. These are the electrical characteristics seen at their interfaces. Scattering parameters allow you to design an amplifier with approximately the same gain and noise figure specified by the manufacturer, as long as you follow certain rules of analysis. Unfortunately, for most of us, following these rules by longhand can be an exceedingly ambitious and time-consuming task.

Computer needed

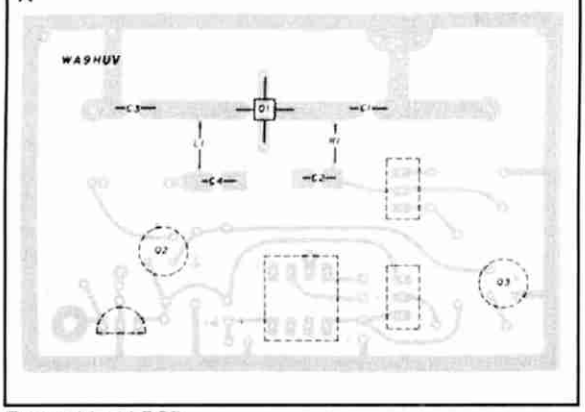
If you have access to a personal computer *and* a suitable program, you can accomplish designs quickly and with relative ease. Even so, you wouldn't expect to develop a design from scratch on a weekend.

Some years ago I wrote a relatively simple computer program in BASIC for purposes of designing low noise amplifiers. With this program, using data specified by the manufacturer, I found that I could realize a design in short order.

I've built and tested a number of amplifiers with this program, employing various types of transistors — including both bipolar and GaAsFETs. My designs agreed with the manufacturer's data sheets, increasing my confidence in the program.

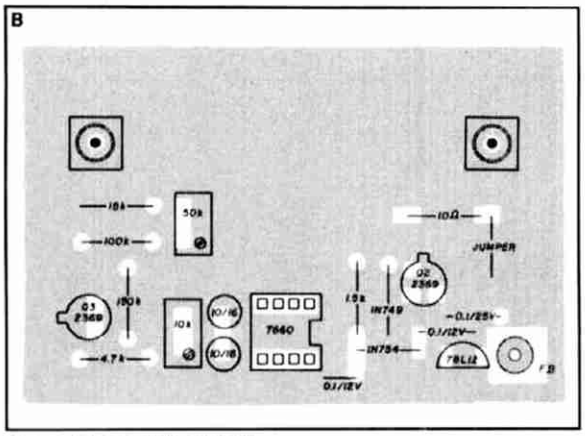
FIGURE 1

A



Trace side of PCB.

B



Groundplane side of PCB.

See page 97 for pc board groundplane and trace layout.

The weekender

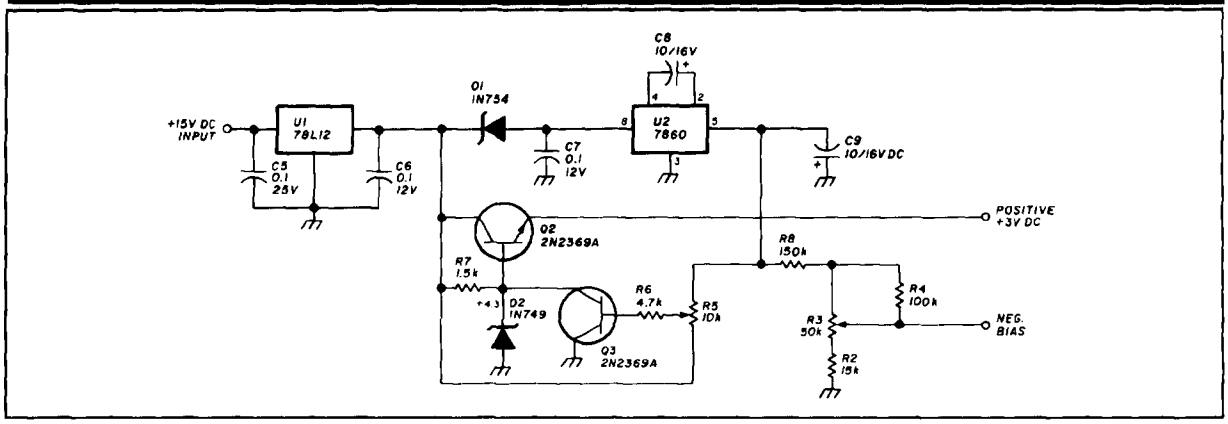
This article is about one of these designs. Centered near 1296 MHz, it employs a NEC-70083 GaAsFET. The 70083 was introduced a number of years ago and is now available at reasonable cost. It uses a 0.5 micron gate and is hermetically sealed in a stripline package.

To duplicate this amplifier, copy the microstrip layout shown in **fig. 1**. Notice that all traces are 50 ohms, printed on G-10 (glass-epoxy) double copper-clad pc board. No tweaking or tuning is required.

Figure 2 shows how the amplifier is powered. A +5Vdc potential is obtained by using a 78L12 regulator and a series-pass transistor driving an Intersil 7660 voltage inverter for negative gate bias. A safety circuit[1] is included; this shuts off the drain voltage in case the bias circuit fails. **Figure 3** is a schematic diagram of the GaAsFET amplifier.

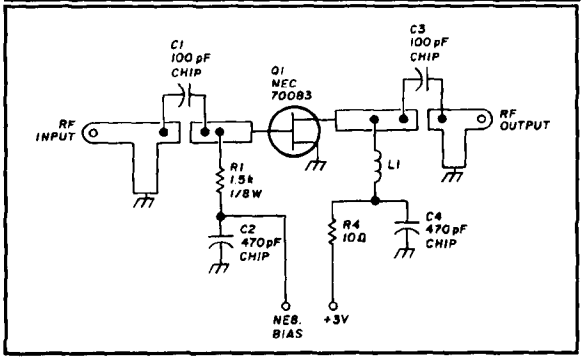
A curve of gain-vs-frequency is illustrated in **fig. 4**. The gain is flat within a half dB from about 1250-1320 MHz. (The improved pc board layout in **fig. 1** maintains flatness over a narrower band — approximately 100 MHz.) A word of caution; the layout of **fig. 1** should not be scaled to another frequency because scattering parameters are frequency sensitive.

FIGURE 2



Schematic diagram of power supply/regulator.

FIGURE 3



Schematic diagram of GaAsFET amplifier.

FIGURE 4

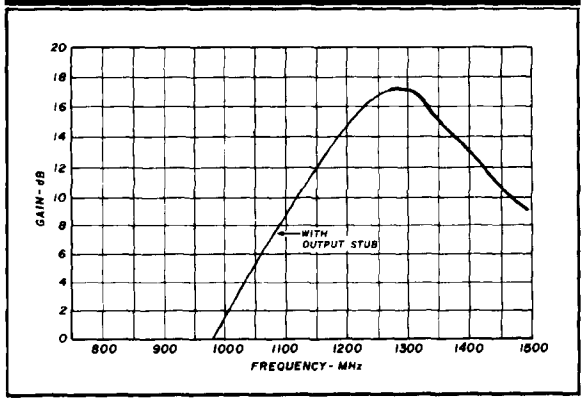


Chart showing curve of gain versus frequency.

Parts List

Capacitors
2 100-pF chip (Mouser—21CC610)
2 470-pF chip (Mouser—21CC647)
1 0.1-μF disc 25 volts
2 0.1-μF disc 10 volts
2 10-μF electrolytic 16V

Potentiometers
1 10k multiturn (Mouser—ME323-4290W-10k)
1 50k multiturn (Mouser—ME323-4290W-50k)

Resistors
1 10 ohm 1/4 watt
1 1.5k 1/8 watt
1 1.5k 1/4 watt
1 4.7k 1/4 watt
1 15k 1/4 watt
1 100k 1/4 watt
1 150k 1/4 watt

Semiconductors
1 1N754 Zener Diode
1 1N749 Zener Diode
2 2369A Transistor
1 7660 IC
1 78L12 Regulator
1 NEC70083 Planar Transistor (California Eastern Labs)

Miscellaneous
2 SMA Connectors
1 8-Pin DIP Socket
1 PCB (FAR Circuits $6.25)

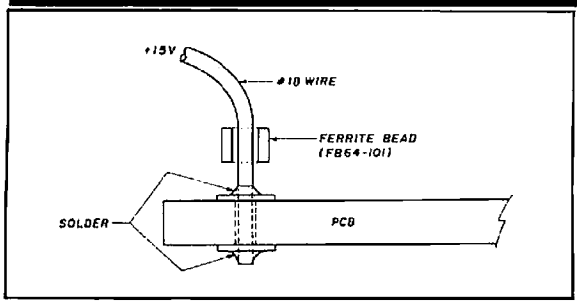
Parts Sources
California Eastern Labs, 3260 Fay Street, Santa Clara, California 95060
Digi-Key, 701 Brooks Avenue South, P.O. Box 677, Thief River Falls, Minnesota 56701
FAR Circuits, 18N640 Field Court, Dundee, Illinois 60118
Mouser Electronics, 2401 Highway 287 North, Mansfield, Texas 76063
Radiokit, P.O. Box 973, Pelham, New Hampshire 03076
Radio Shack (see your local store)

It should be recognized that while the manufacturer specifies the optimum noise figure to be about 0.7 dB at 1296 MHz with an associated gain of 18.5 dB,[2] the actual noise figure will be somewhat higher and the gain lower. This is due to such factors as pc board dielectric loss, source lead inductance, or inaccuracies in microstrip dimensions. Measured gain for this particular amplifier is 17dB when Ids = 10 mA. Differences in dielectric constant between one manufacturer's board material and another's, or between different production runs from a given manufacturer, can influence performance. A value of $e_r = 4.4$ was selected from a published table.[3]

Gain increases with drain current, peaking out at 19.5 dB at about 40 mA, but the manufacturer's data calls for a drain current of 10 mA for minimum noise figure.

Through-grounds are made on the pc board in **fig. 1** by passing no. 26 tinned copper busbar through the ground holes and soldering on both sides. In this way, the ground on the trace side of the board is connected to the ground plane with minimum inductance. This is particularly important where the stub on the gate side of the transistor is connected via a through hole to the ground-plane side of the board, and where the transis-

FIGURE 5



Ferrite bead placement on the +15 volt Vdc line.

tor sources are similarly through-grounded (See fig. 5for details on RFI proofing the +15 Vdc input line.

C1 and C3 are 100-pF chip capacitors; C2 and C4 are 470-pF chips. R1 is a 1.5k 1/8-watt resistor soldered directly to the traces with short leads. L1 is wound, using a 1/16″ drill bit as a mandrel, with 9 turns of no. 24 enamel copper magnet wire; the turns are spaced slightly. R3 is the gate bias pot; R5 sets the drain voltage to +3 volts.

Adjustments

Before soldering the GaAsFET to the pc board, adjust the negative bias and protective circuit. Temporarily connect a 270-ohm resistor from the junction of L1 and R4 and ground to simulate transistor-drain current. Then adjust R6 until the drain voltage across the 270-ohm resistor is 3.0 Vdc. When pin 5 of the 7660 is then shorted to ground, or if the 7660 is removed from its socket, the positive 3 Vdc ramps down to zero.

Shielding

The 1296-MHz amplifier performs noticeably better when the assembly is enclosed in a shielded box. Form brass strip 1/4″ wide and 0.032″ thick into a 2″ x 3″ rectangle and solder it to the copper band around the trace side of the board. Now form a 0.015″ thick piece of aluminum into a tight-fitting cover. Use a pair of 2-56 screws to hold the cover in place through tapped holes in the brass rectangle.

A final note

I make no particular claims for superior performance for the amplifier described here. It will win few contests for the lowest noise figure, but on-the-air tests make it clear that "store-bought" or homebrew converters come to life when you use it. You be the judge.

References

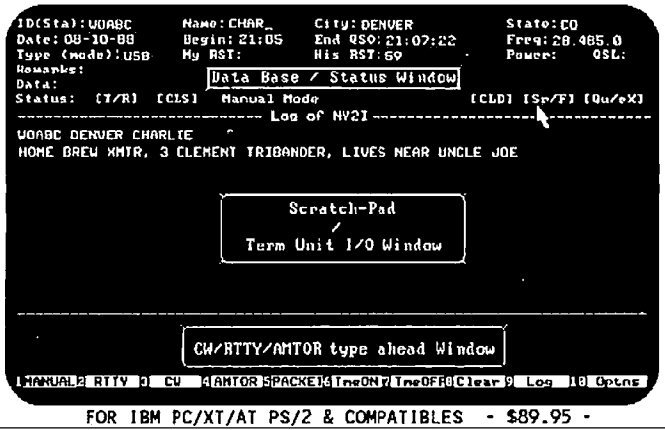
1. Norm Foot, WA9HUV, "Safe Power for your GaAsFET Amplifier," *ham radio*, November 1982, page 20.
2. California Eastern Laboratories, Inc., NEC Data Sheet, NE700 Series, January 1983.
3. Tri T. Ha, "Solid State Microwave Amplifier Design," John Wiley & Sons, New York, 1981, page 292.

Bibliography

1. George D. Vendelin, "Design of Amplifiers and Oscillators By the S-Parameter Method," John Wiley & Sons, New York, 1981.
2. T.C. Edwards, "Foundations For Microstrip Circuit Design," John Wiley & Sons, New York, 1981.

Aries—1
Amateur Radio Integrated Entry System

ALL MODE SOFTWARE



FOR IBM PC/XT/AT PS/2 & COMPATIBLES - $89.95 -

Aries—1...

... Inserts DATE / TIME from Computer - FREQUENCY / MODE from Transceiver (certain Kenwood and Icom models) into log.
... Interfaces with Kantronics KAM and AEA PK-232 Terminal Units for totally integrated ON-SCREEN I/O.
... Works with a Mouse and/or Function Keys for fast and easy control of Terminal Units and Data Entry.
... Is useful with or without interfacing to Terminal Units and Transceivers.
... Changes TU Modes, operating parameters and files data into the Log file with the press of a key or the click of a mouse.
... Has a Contest Mode and automatic string replacement capability which give new meaning to quick exchanges.
... Has Automatic Dup checking and the ability to search / print data base by Call, Country, Freq, QSL info, etc.
... Lets you run other programs (or access DOS) while staying resident in memory along with your data.
... Logs voice contacts, while simultaneously connected to a packet mail box and down-loading messages into a capture file.

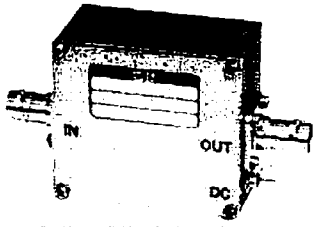
An Extremely useful program! Most Aries-1 Users "fire up" the program whenever they are in the shack. Whether operating Voice, AMTOR, Packet or any other mode, you will enjoy having your Log available on screen simultaneously with your Terminal Unit and access to your other ham software just a keypress away.

VISA - - Our 10th Year of delivering Quality Software to the International market - - MasterCard

✓ 159

asmtor ITC
PO Box 1067 - Vestal, NY 13851 - (607-748-9028)

THE LAST AMPLIFIER YOU WILL EVER NEED!
7MHz - 1300 MHz



ONE AMPLIFIER MANY APPLICATIONS:

- Receiving-Ultra high dynamic range-Low noise.
- Transmitting-Driver or final...1 watt linear output.

Gain	15 dB ± 1dB
IP3	+ 44dBm
IP2	+ 73dBm
N.F	HF-UHF 4.5dB (typ)
1dB Comp	+ 30dBm
Connectors	BNC

PRICE $199
Add $4.00 ship USA
CA Res add 6%

ADVANCED MILLIWAVE LABORATORIES, INC. ✓ 160
820 HAMPSHIRE RD., A3
WESTLAKE VILLAGE, CALIFORNIA 91361
TEL. (805) 495-7858

'A' SOLID-STATE 75A-4 RECEIVER

By James M. Larson, KF7M, 2245 Ross Avenue, Idaho Falls, Idaho 83406

Complete details for updating this classic radio

I have done a solid-state conversion of the Collins 75A-4 receiver. My intention was to "get the tubes out," yet retain or improve the original operating features and performance. I wanted a receiver that looked and felt like a 75A-4, but with negligible frequency drift and improved intermodulation distortion (IMD) and overload capability. I was also looking for steeper skirts on the i-f passband and a noise limiter that was effective on the "woodpecker."

I wanted to keep all the original RF, oscillator, i-f, BFO and VFO coil structures, and their associated bandswitches. The original mixing scheme would remain. An additional mechanical filter would be inserted in series with the existing i-f filters.

The end result is a receiver that, from all external appearances, is a 75A-4 (**Photo A**). But when you open the lid, you see the uncluttered view in **Photo B** — and no tubes!

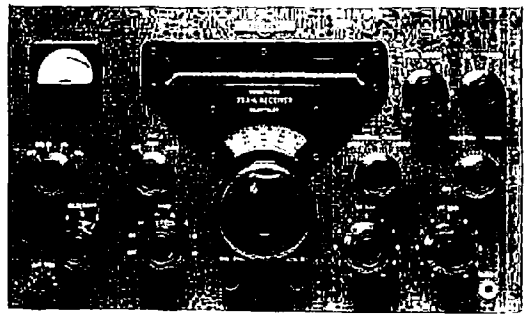
The lack of background interference and hash is noticeable when you compare the new receiver with the unmodified version. The measured IMD and blocking capability are also greatly improved.

Performance characteristics

Table 1 shows performance specifications for the more important parameters of the solid-state receiver, compared to the vacuum tube original. The data is the result of comparative measurements made on a vacuum tube 75A-4 and the solid-state version.

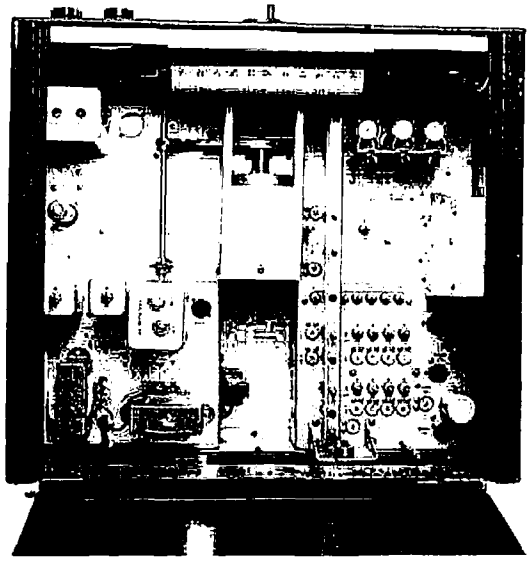
With the exception of receiver sensitivity, all other parameters of the solid-state conversion are improve-

PHOTO A



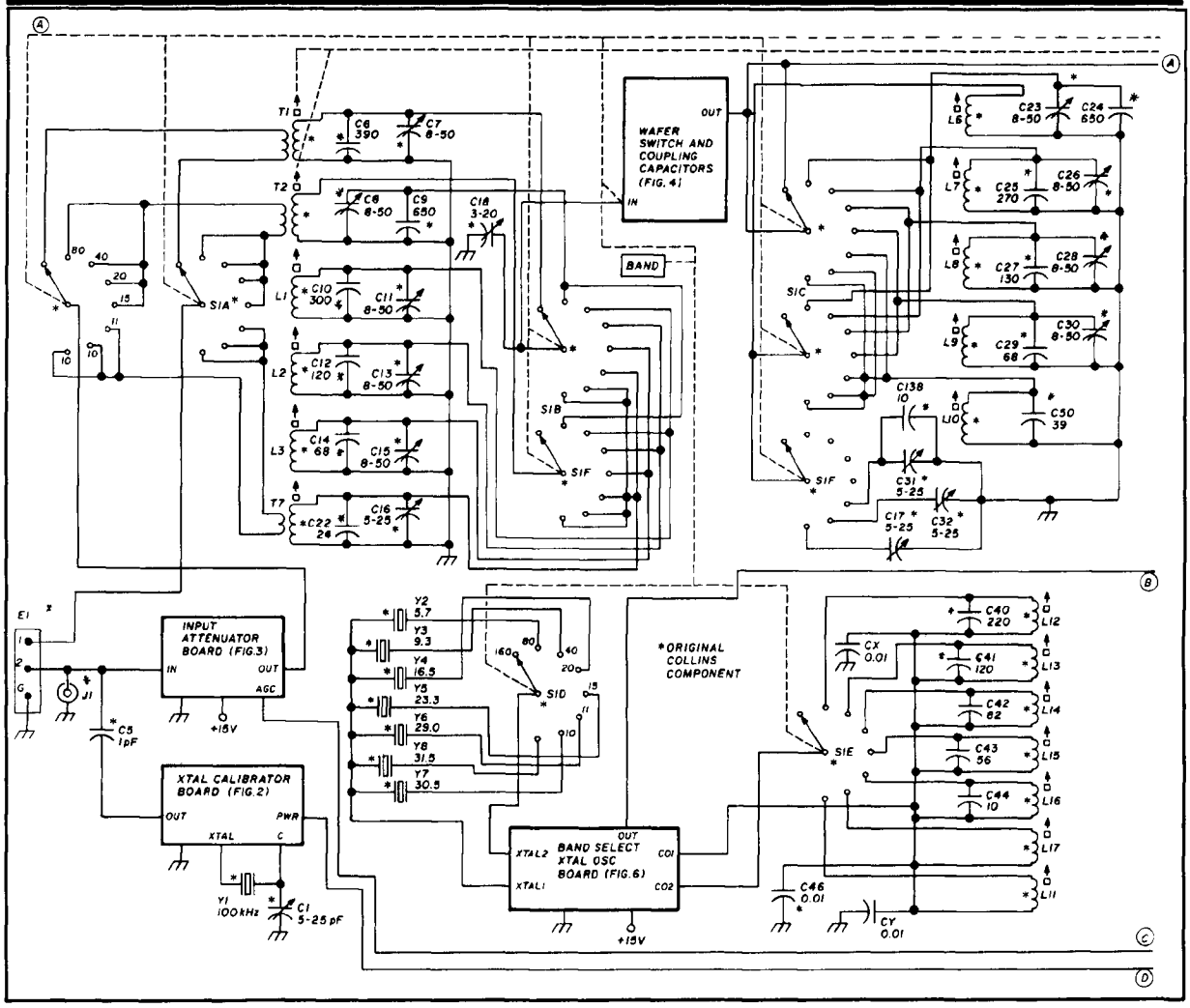
Front view of the 75A-4 receiver.

PHOTO B



Top inside view of the 75A-4 receiver.

FIGURE 1



Overall circuit diagram of the receiver.

ments over the original. The high sensitivity of the vacuum tube receiver was reduced to enhance the IMD and overload capability. The input noise of the solid-state version still remains below the typical background and galactic noise from the antenna.[1,2]

Getting started

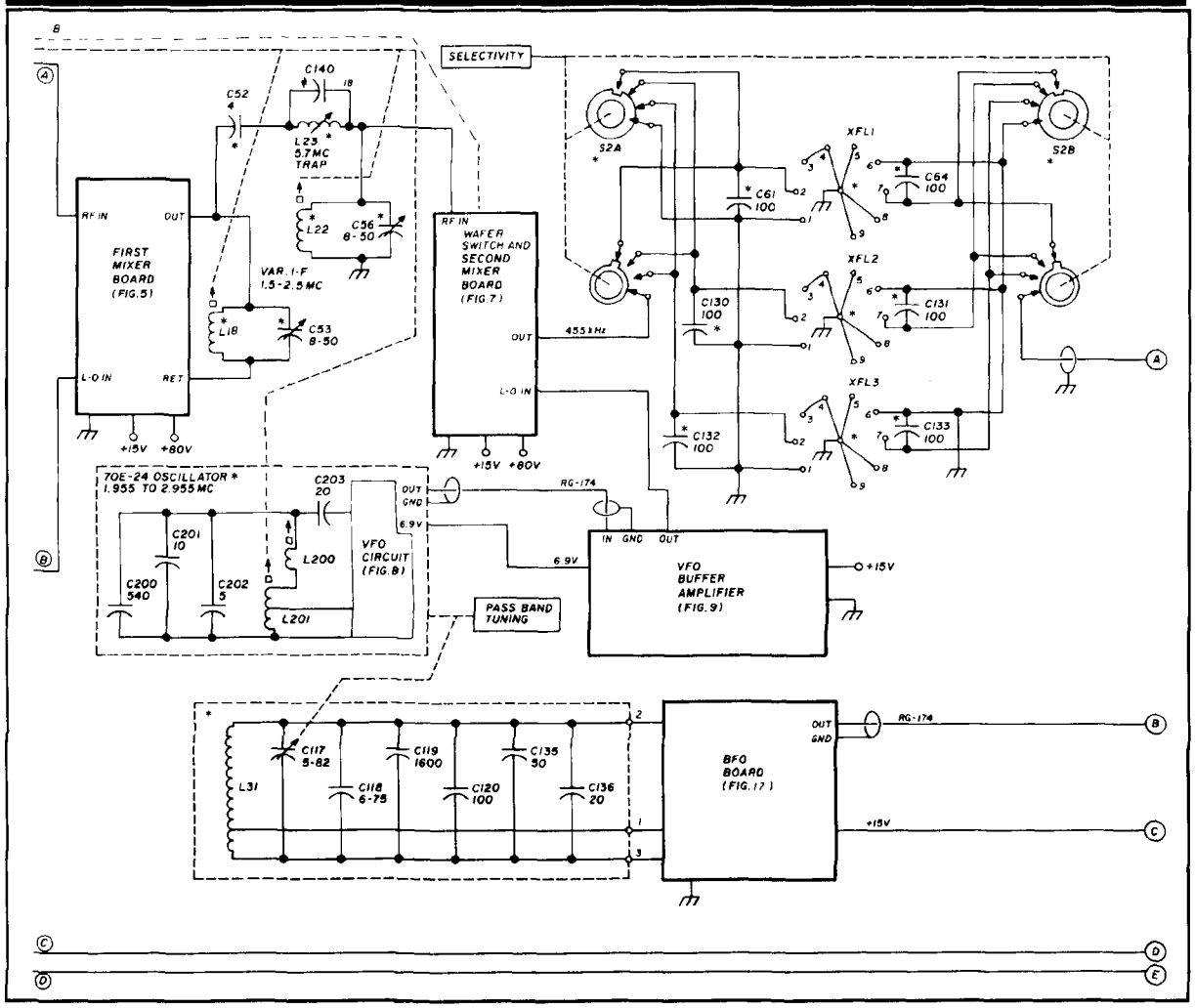
The first thing I did was acquire two 75A-4s. One unit was used as the comparison standard. I removed everything from the other 75A-4 except the RF coils, oscillator coils, variable i-f coils, crystal sockets, bandswitch assembly, and the sockets and switch for the mechanical filters.

The wiring that remained included the interconnecting wires between the bandswitch, its associated coils and crystal sockets, the mechanical filter selection switch, and the interconnecting wiring to the filter sockets. I had removed everything else, leaving an almost bare chassis.

I also stripped out the tube sockets and all wiring at the base of the tube sockets in the permeability tuned oscillator (PTO). I didn't disturb the oscillator circuit in the PTO hermetic enclosure at this time. Next I opened, cleaned, and checked the i-f cans, BFO enclosure, and the rejection filter enclosure. The megacycle dial drum, the kilocycle dial, and their pointers were cleaned and temporarily stored with the front panel. I cleaned the chassis to remove dust and stains, then remounted the i-f cans, BFO enclosure, and rejection filter enclosure.

I cut an aluminum plate to cover the portion of the chassis on the right side as viewed from the front that was riddled with holes from remnants of tube sockets, transformers, and other hardware I'd removed. The tube sockets on the left chassis, and those not easily covered

FIGURE 1



on the right, were filled with button-type hole covers. A nine-pin tube socket was mounted on the right side (see **Photo C**) for the additional 3.1-kHz mechanical filter to be added to the i-f section.

Much of the circuit was built "daub-a-gob" style on unetched copper-clad vector board. These boards are still in place, but I hope to replace them in the future.

Circuit description

The overall circuit diagram for the receiver is shown in **fig. 1A-D**. Components retained from the original receiver are also shown in **fig. 1**, accompanied by an asterisk and the component designators used by Collins on the original receiver schematic. The new solid-state circuits are shown only as circuit blocks on this diagram. The solid-state circuits comprising these blocks are described in more detail later. If you own a 75A-4, you might be interested in comparing **fig. 1** with the block diagram and schematic in your 75A-4 instruction book.

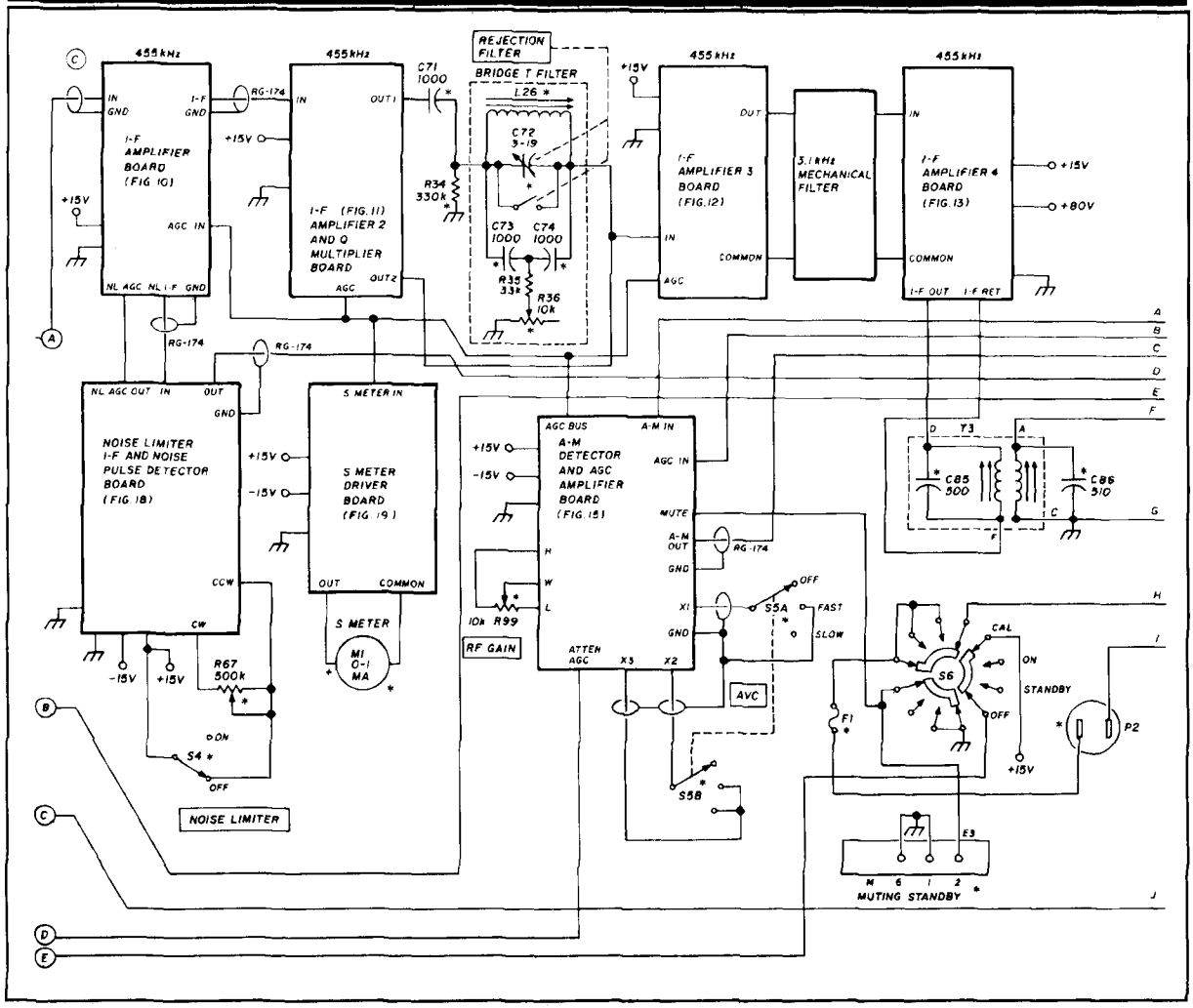
The circuit diagram shows that the new solid-state version retains the same mixing scheme and the same basic topology as the original. It differs from the original as follows:

- An AGC-controlled input attenuator has been added at the receiver input.
- There is no RF amplifier. The antenna and RF coils are now capacitively coupled, forming a double-tuned network ahead of the first mixer.
- An additional 3.1-kHz mechanical filter has been placed in the i-f amplifier to improve shape factor and i-f rejection.
- I used a gated noise limiter that has its own separate i-f amplifier for impulse noise identification.
- The S meter is driven from a special driver board.

Crystal calibrator

Figure 2 shows the schematic of the 100-kHz crystal-calibrator circuit. The active element is a CD4011 CMOS

FIGURE 1



quad nand gate. Gate $U1_a$, crystal Y1, resistors R1 and R3, and capacitors C1 and C3 comprise a Pierce oscillator. Gates $U1_b$ through $U1_d$ buffer the oscillator output and square up the oscillator signals to enhance its harmonic output. Positive 15 volts is applied to the calibrator when the front panel AC power switch, S6, is in CAL position.

Capacitor C1 and crystal Y1 are components from the original receiver. The new oscillator was built on a small piece of vector board that was mounted close to the antenna connector. This board is mounted underneath the input attenuator board and may be seen in the lower righthand corner of **Photo D**. The output signal from the calibrator circuit is coupled to the antenna input connector through capacitor C5, as shown in **fig. 1A**.

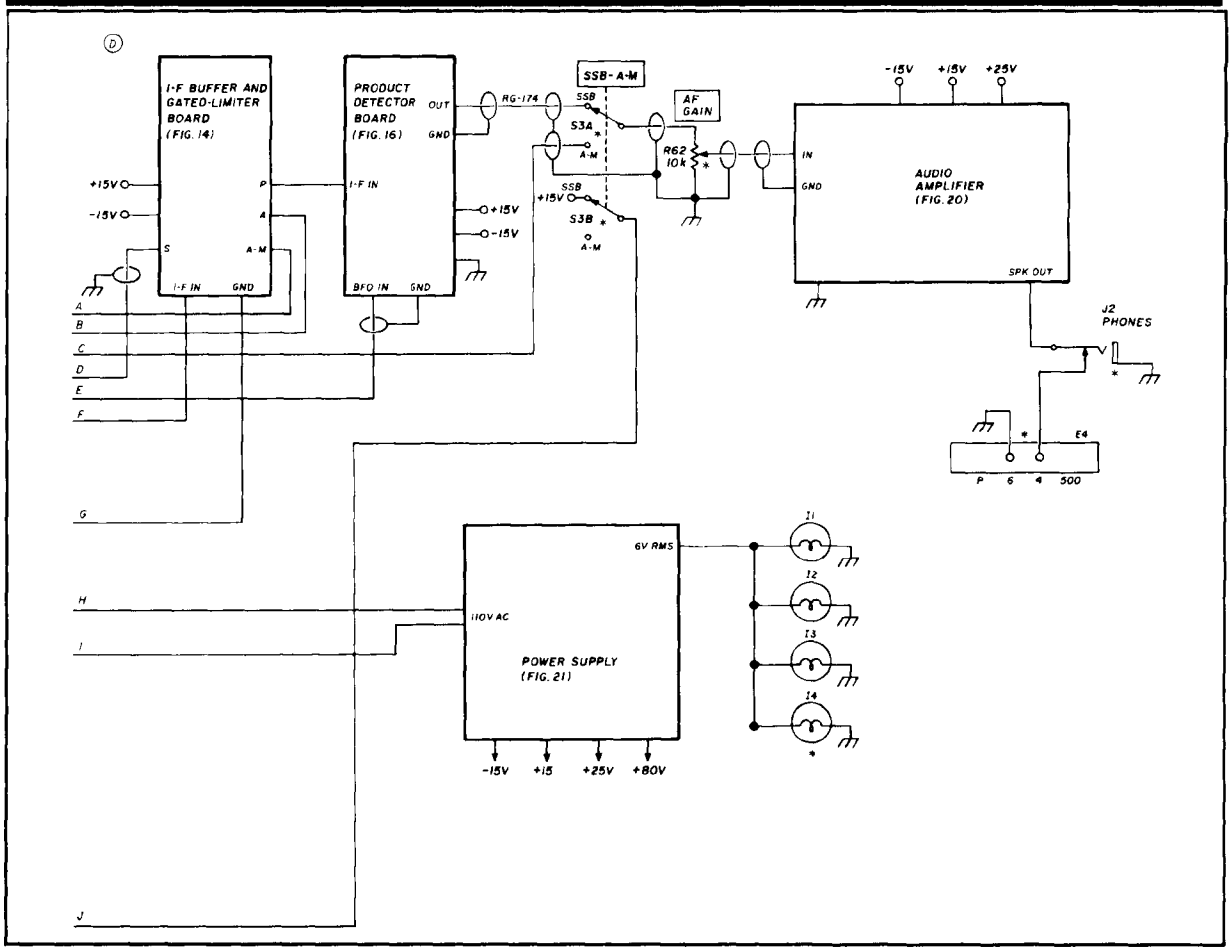
Input attenuator

The conversion transconductance first-mixer is high enough that an RF amplifier is not needed. AGC ahead of the first mixer is provided by a voltage-controlled input attenuator in series with the antenna input and antenna coils. The input attenuator is mounted on the input attenuator board (**fig. 1A**). This board is shown schematically in **fig. 3**.

The input attenuator board consists of a Mini Circuits SAY-1 high-level, double-balanced diode mixer and transistor, Q1. The double-balanced mixer acts as an attenuator by feeding its DC-coupled i-f port with a DC voltage derived from the AGC bus. The SAY-1 has an insertion loss of about 3 dB and provides about 40 dB of attenuation with full AGC.

The SAY-1 requires about 20 mA of DC into its i-f port for minimum attenuation. This current is provided by emitter follower Q1. Resistors R1 and R2 limit the current into the i-f port to about 20 mA for an AGC input of 10 volts to the base of Q1. Capacitors C1 and C2 filter the AGC input to the SAY-1. Resistor R2 provides a 50-ohm termination to the SAY-1 i-f port.

FIGURE 1



Double-tuned input network

Originally the 75A-4 had an RF amplifier stage between the antenna and RF coils. This stage has been replaced with the passive-coupling network shown in fig. 4. The antenna coils and the first RF coils now comprise a double-tuned input network on the 10 through 80-meter bands. The purpose of switch S1-G is to change the coupling capacitance between the antenna and RF coils when different bands are selected. The S1-G switch is a Centralab YD wafer that you must add to the original bandswitch.

As shown in fig. 4, wafer switch S1-G is positioned on the existing bandswitch assembly. Its location is critical because the stray capacitance between the wafer switch and antenna coils L3, T2, and T7 is used for coupling. This capacitance is the right amount for coupling on 20 through 10 meters. Additional capacitance is added (as shown in fig. 7) for 40 and 80 meters. The input network is single tuned on 160 meters.

It's not difficult to add the wafer switch S1-G to the bandswitch assembly. Collins provides access holes on the back of the receiver that allow the bandswitch wafer-supporting hardware to be disassembled. Part of the added wafer switch, S1-G, must be cut away for lack of room; coil T2 gets in the way. I did this with a Dremel tool.

I'd like to re-emphasize that even with the insertion loss of the attenuator and the absence of an RF amplifier, the receiver still provides an input sensitivity of approximately 0.6 μV. This input noise level is quite acceptable because it's small when compared with the noise from a typical resonant antenna. The small loss of sensitivity, as compared with the original 75A-4, is repaid by improved IMD and overload capability.

First mixer

The output signal from the RF coils is mixed with that from the band-select crystal oscillator to derive a signal falling between 1.5 and 2.5 MHz. This is the frequency of the variable i-f of this receiver. Mixing is accomplished in the first mixer located on the first mixer board of fig. 1B. The schematic of this board is shown in fig. 5.

The mixer is a dual-gate MOSFET (Q1). Q1 is connected in cascode with Q2, which has a high collector breakdown voltage. Its collector is powered from an 80-

TABLE 1

Comparative performance specifications

Specification	Original vacuum tube 75A-4	Solid state 75A-4
Sensitivity measured at		
29.5 MHz	0.4 μV for (s + n)/n = 10 dB	0.6 μV for (s + n)/n = 10 dB
7.3 MHz	0.28 μV for (s + n)/n = 10 dB	0.6 μV for (s + n)/n = 10 dB
I-F selectivity	3.1 kHz at −6 dB	3.0 kHz at −6 dB
6 to 60 dB	5.1 kHz at − 60 dB	4.1 kHz at −60 dB
3.1-kHz filter	Shape factor = 1.65	Shape factor = 1.37
I-F rejection	Greater than 80 dB	Greater than 130 dB
Image suppression	Approximately 50 dB above 21 MHz Greater than 80 dB below 14.5 MHz	Same
IMD		
Level of two-tone RF inputs at 14.02 and 14.04 MHz to produce Third order IMD product at 14.06 MHz giving (IMD product + n)/n = 3 dB	−67 dBm	−45 dBm
1-dB compression		
desired signal of 10 V at 14.02 MHz; undesired signal at 14.04 MHz	1-dB compression of the desired signal occurs for undesired signal amplitude of −47 dBm	1-dB compression of the desired signal occurs for undesired signal amplitude of −20 dBm
AGC	Audio rise < 3 dB for RF inputs of 5 μV to 0.2 volt	Audio rise < 3 dB for RF inputs of 3 μV to >1 volt
AGC time constants		
AGC fast	Rise time = 10 ms Release time = 0.1 sec	Rise time equivalent to 10 ms or less for 60-dB step. Release time ≅ 0.2 sec
AGC slow	Rise time = 10 ms Release time = 1 sec	Rise time equivalent to 10 ms or less for 60-dB step. Release time ≅ 2 sec
Audio bandwidth	−3 dB 100 Hz to 5 kHz	−3 dB 300 Hz to 3 kHz
Noise limiter	Passive diode limiter in audio circuit	Gated diode limiter in i-f circuit
Frequency stability	After 30-minute warmup, drift during any 10-minute period does not exceed 100 Hz	15 Hz in first minute following a cold start. Approximately 30 Hz per hour thereafter
For line voltage change of ±10 percent	Does not exceed 100 Hz	Less than 1 Hz
Power input at 115 VAC	85 watts	35 watts

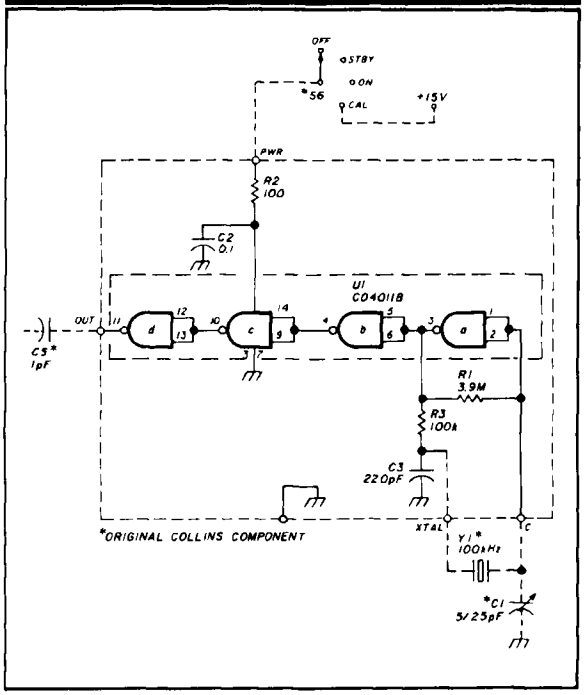
volt power supply. Q1 is biased to optimize conversion transconductance.

The local oscillator signal is applied to gate 2 of Q1. Slug-tuned inductor L18 is terminated on the 80-volt supply through decoupling network C3 through C5 and resistors R3 and R4. Capacitor C47, which was connected across L18 in the original vacuum tube receiver, was increased to 390 pF and connected directly to Q2's collector.

The oscillator signal at gate 2 of MOSFET Q1 is approximately 5 volts peak-to-peak on all bands. The 1-pF capacitor, C9, connected to gate 2 of Q1 provides an isolating test point for measuring local oscillator signal amplitude with an oscilloscope and test probe. The oscillator voltage at gate 2 is the measured value read by the oscilloscope multiplied by the ratio $(C_{probe} + C9)/C9$. This test point is useful for setting local oscillator output level.

This cascode technique was so effective that I used it again in the second mixer and the last i-f stage, because these stages are also susceptible to output saturation with large amplitude signals.

FIGURE 2



100-kHz crystal calibrator schematic.

Band-select crystal oscillator

This oscillator is shown schematically in **fig. 6**. The topology of the solid-state oscillator is much the same as that of the vacuum tube version in the original receiver.

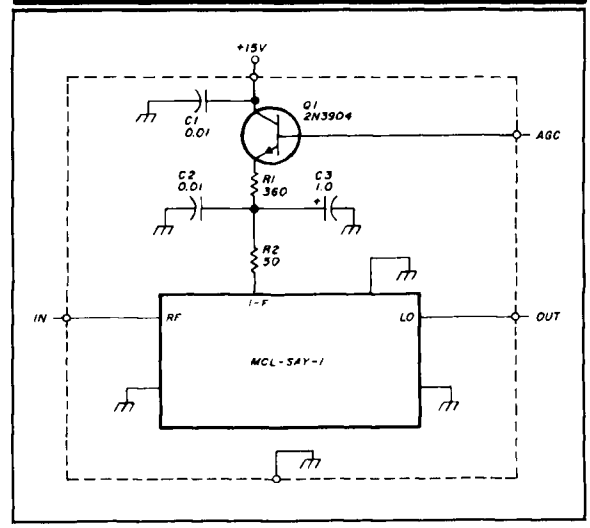
The active element in this circuit is a dual JFET, U431. In the original receiver, L11 and L17 (**fig. 1A**) were paralleled by 47-pF capacitors. These capacitors were removed and a single 47-pF capacitor, C1, was connected to the drain of $Q1_a$. (See **fig. 6**.) This was to eliminate a high-frequency parasitic oscillation caused by the long wire runs from the bandswitch to coils L11 through L17. This parasitic just couldn't be tamed satisfactorily in any other way. Capacitors CX and CY were added at the bottom terminals of L11 and L12, as shown in **fig. 1A**. This additional bypassing also helped cure the parasitic problem.

The parallel capacitance across coils L14 through L16 was reduced by approximately 47 pF so that they would resonate properly. No change was required in the capacitance paralleling L12 and L13, as these coils had sufficient adjustment range to resonate.

Second mixer

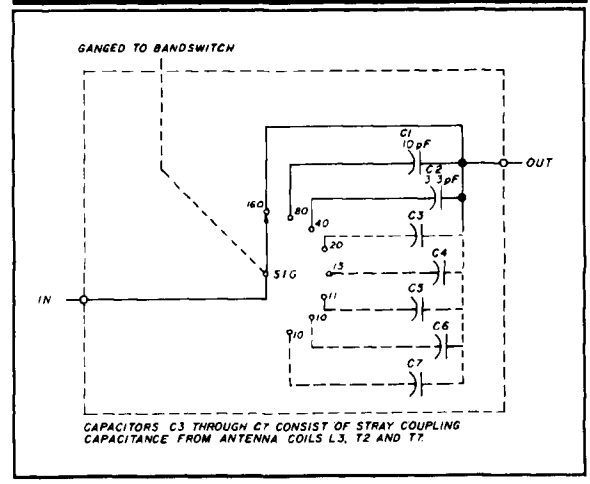
The output signal from coil L22 of the variable i-f (**fig. 1B**) is fed, through wafer switch S1-H. This signal is mixed in the second mixer with the VFO output to develop the 455-kHz i-f. The schematic is shown in **fig. 7**. The design of the second mixer is similar to the one

FIGURE 3



Input attenuator schematic.

FIGURE 4



Wafer switch and coupling capacitors between antenna and RF coils.

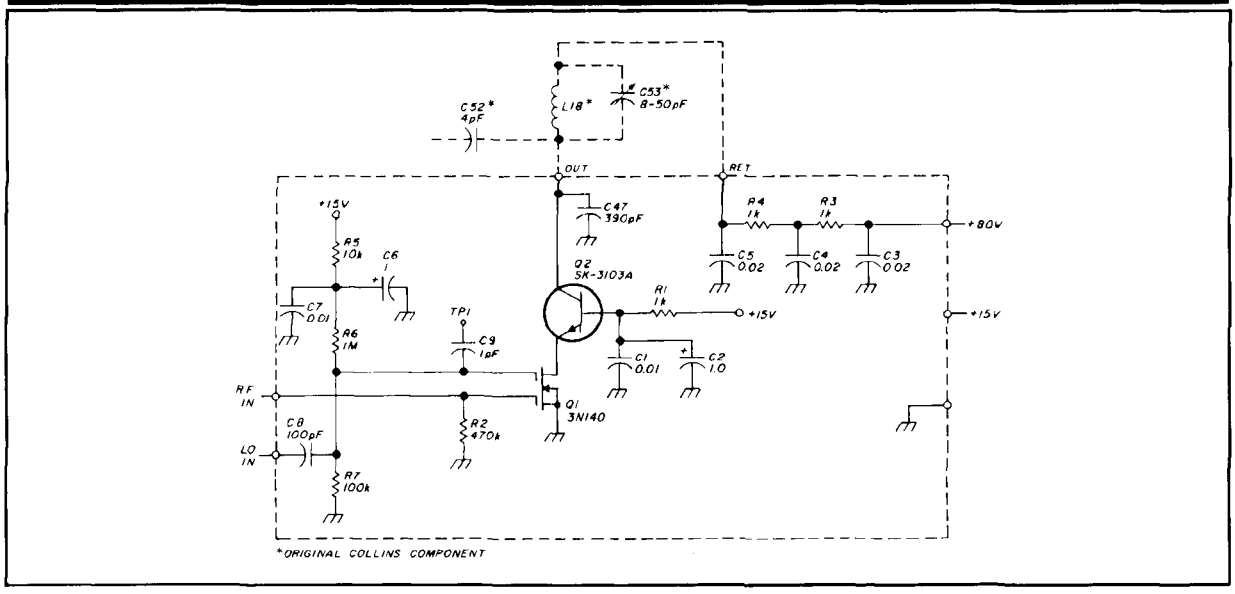
used in the first mixer. The VFO output voltage is connected to gate 2 of Q1. The voltage amplitude at gate 2 is approximately 8 volts peak-to-peak.

The S1-H switch is a Central Lab YD wafer that's added to the original band switch at the partition separating L18 and L22. S1-H is used to switch in additional attenuation when you select the 160-meter band.

Permeability tuned VFO

The permeability tuned oscillators used in Collins VFOs have always been outstanding for their smoothness, freedom from backlash, and frequency stability. The VFO shown in **fig. 8** is even better because its frequency drift is almost nil. At constant temperature this

FIGURE 5



First mixer schematic.

oscillator drifts less than 5 Hz in the first minute after turn-on and about 5 Hz per hour thereafter.

Modify the VFO by first removing the tube sockets and all the circuits connected to them. A small thin piece of aluminum covers the tube-socket mounting holes. I opened the sealed portion of the VFO. It contains inductors L200 and L201, and capacitors C200 through C203 and C207. Capacitor C207 was disconnected and a new tap was made on L201 eight turns from the bottom. (C207 was originally tapped into L201 at about ten turns). *I lowered the tap on L201 because that coil is now being* driven from the lower impedance seen at the source of Q1. C207 was replaced by C1 and C2 which are polystyrene caps.

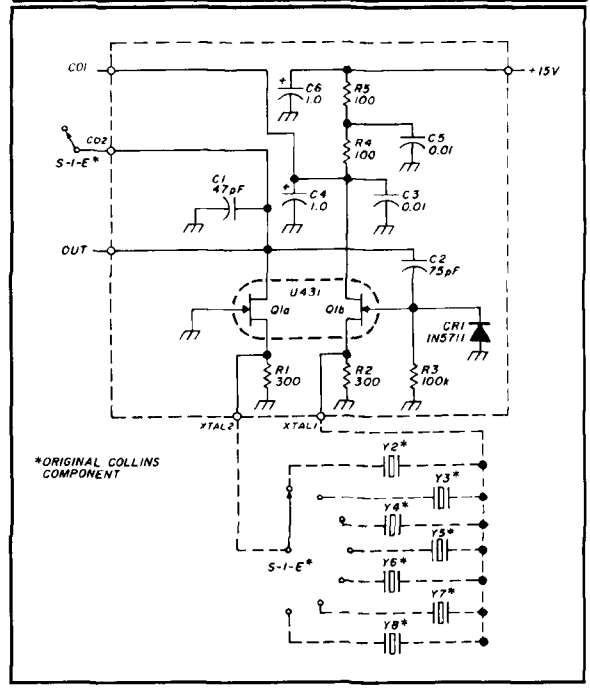
Diode CR_1, in conjunction with C203 and R1, allows the oscillator to generate negative self-bias through grid-leak action. Q2 serves as a buffer between Q1 and the outside world. Capacitor C8 at the collector of Q2 helps reduce the harmonic content at the VFO output.

VFO buffer amplifier

The output of the VFO drives the VFO buffer amplifier in fig. 9. This amplifier serves three purposes. It boosts the signal amplitude from the VFO to about 8 volts peak-to-peak, provides additional filtering to reduce the harmonic content of the VFO signal, and allows the resonant network in the drain of Q1 to be peaked, so that the output of the VFO circuit is flat through its tuning range.

The buffer amplifier board also provides the 6.9-volt power supply for the VFO. This supply consists of an LM329DZ precision voltage reference, (CR_1), and resistor R8.

FIGURE 6

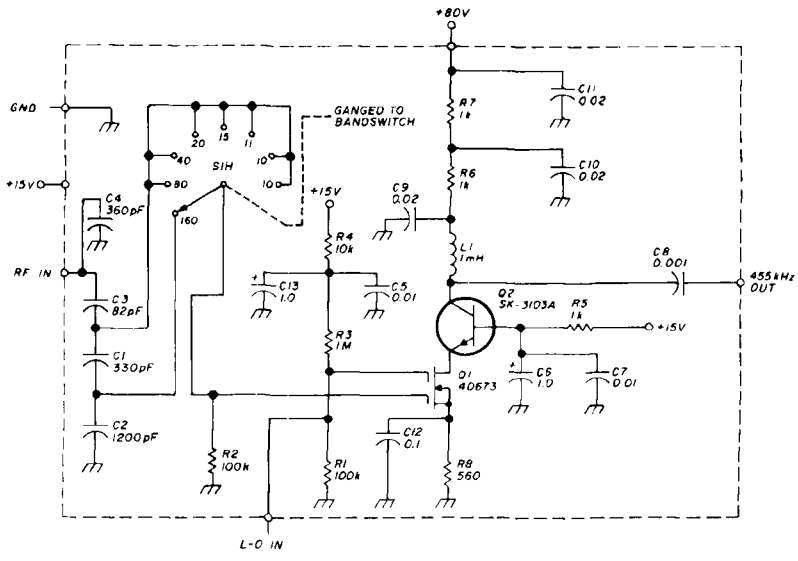


Band select crystal oscillator schematic.

455-kHz i-f amplifier

The 455-kHz i-f section is comprised of the switch-selectable mechanical filters, i-f amplifier boards 1 through 4, bridged-T rejection network, added 3.1-kHz mechanical filter, and the i-f buffer and gated limiter board.

FIGURE 7



Second mixer schematic.

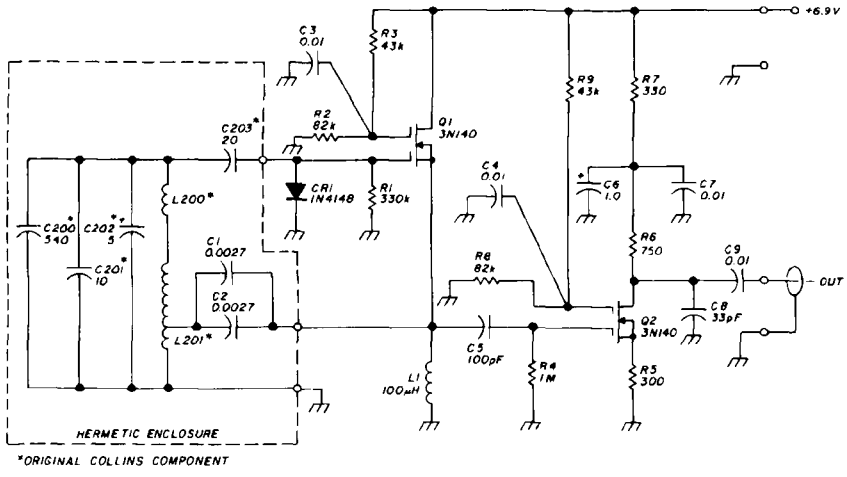
The output of the second mixer is fed to the switch-selectable mechanical filters through the front panel selectivity switch, S2. The output of the selected filter drives the input of i-f amplifier board **1**, shown in **fig. 10**.

Dual-gate MOSFET Q1 on i-f amplifier board 1 is the first amplifier in the i-f chain. AGC is applied to gate 2 of this FET. Dual-gate MOSFET Q2 is the first amplifier in the noise-limiter i-f chain. The noise limiter i-f and its separate AGC bus will be described later.

The output of i-f amplifier 1 drives i-f amplifier 2 and the Q multiplier. This board is shown in **fig. 11**. Q1 provides additional i-f gain and AGC capability. It drives the Q multiplier rejection filter comprised of Q2 and external bridged-T network L26; capacitors C72, C73, and C74; and resistors R34, R35, and R36. The Q multiplier is an exact equivalent of the circuit in the original vacuum-tube receiver. The only difference is that Q2 is used in place of the dual triode in the original.

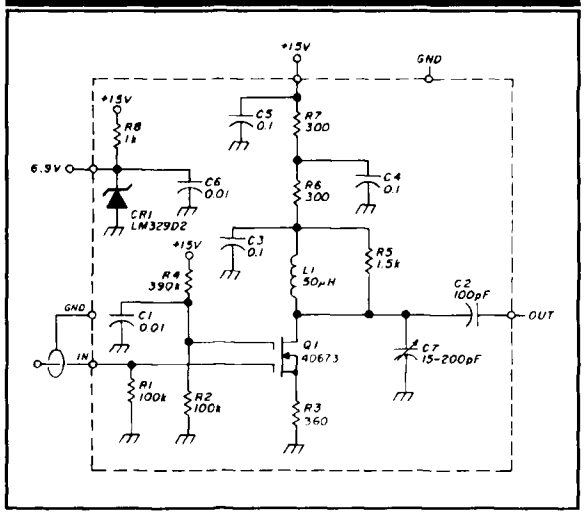
The bridged-T network drives i-f amplifier 3. This board is shown in **fig. 12**. Q1 provides additional gain and AGC capability. Capacitors C75 and C139 and resistor R37 terminate the bridged-T, and are identical to the

FIGURE 8



VFO schematic.

FIGURE 9

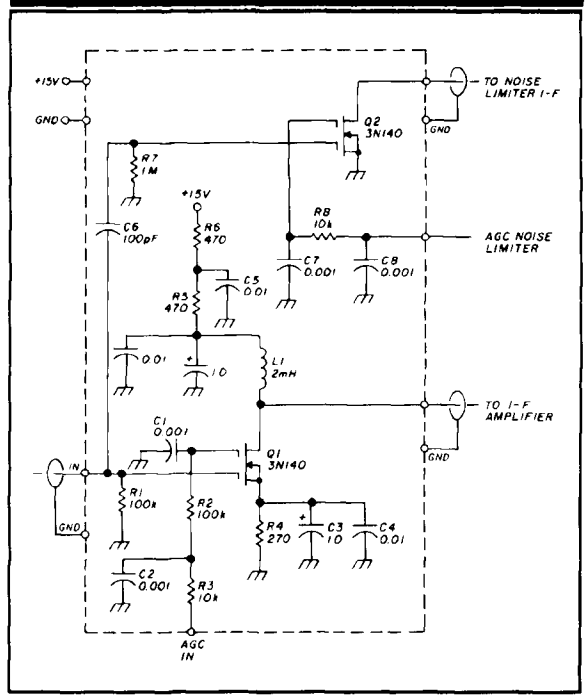


VFO buffer amplifier schematic.

components used in the original receiver. Q1 drives the added 3.1-kHz mechanical filter. The mechanical filter output drives the last i-f stage, made up of the components on i-f amplifier board 4 (see fig. **13**).

Q1, on i-f amplifier board 4, is connected in cascode with Q2. The collector voltage for Q2 is derived from the 80-volt power supply. I-F transformer T3 provides coupling between Q2's collector and the i-f buffer and gated noise limiter. I used the cascode connection, with its 80-volt collector supply, for the last i-f stage. This allows for a large voltage swing.

FIGURE 10



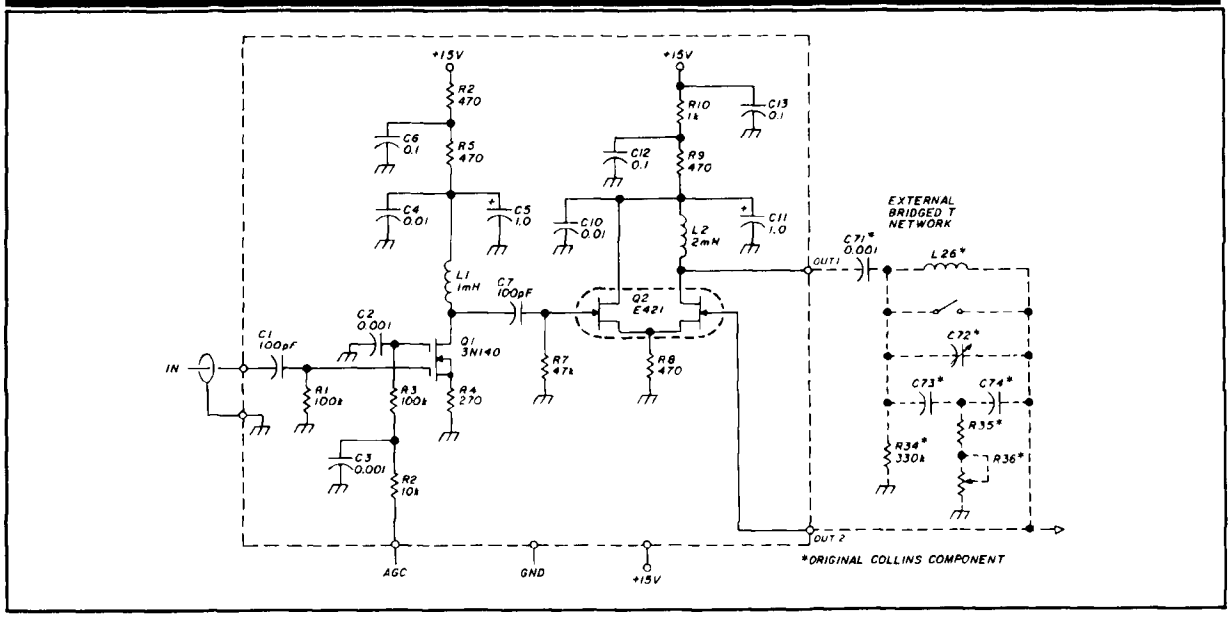
I-F amplifier 1 schematic.

I-F buffer

The last i-f stage output is derived from the secondary of i-f transformer T3, which drives the i-f buffer and gated noise limiter. This board is shown in **fig. 14**.

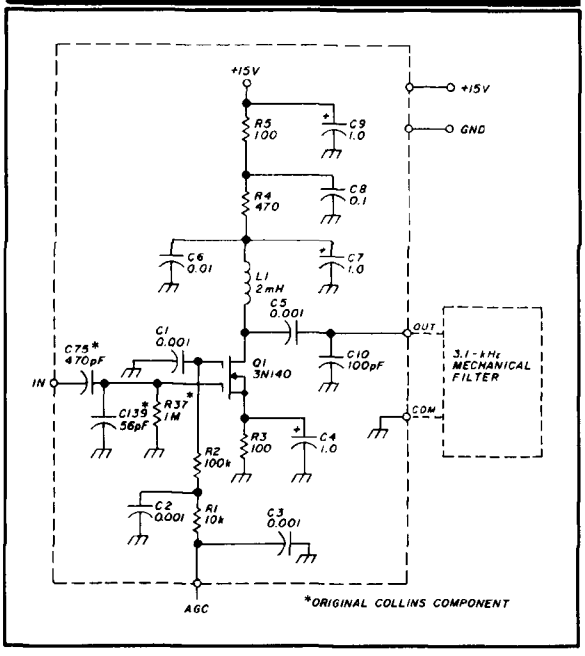
Buffer amplifier U1 on this board provides a high-

FIGURE 11



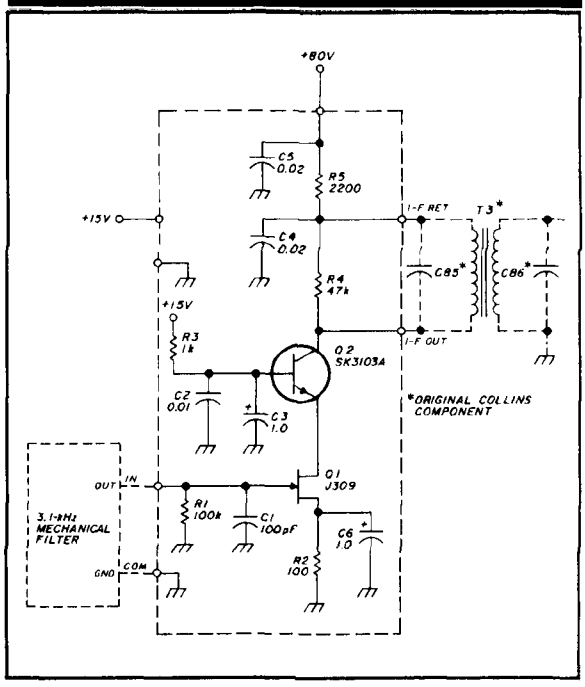
I-F amplifier 2 schematic.

FIGURE 12



I-F amplifier 3 schematic.

FIGURE 13



I-F amplifier 4 schematic.

impedance termination for the secondary of T3. In addition, it provides a low-impedance source of i-f output for the AM detector, product detector, AGC amplifier, and gated noise limiter. The product detector, AM detector, and the AGC amplifier receive their input signals through resistors R7, R6, and R5, respectively.

Gated noise limiter

The noise limiter works as follows (see **fig. 14** for details): U2 and U4 are high-speed, solid-state switches. The internal switch contacts of U2a and U4 are normally closed, and the internal switch of U2b is normally open. Capacitor C1 charges to, and closely follows, the positive peaks of the i-f signal output of U1 through CR_1. Similarly, capacitor C2 charges to the negative peaks of the i-f output signal. The voltage developed across capacitors C1 and C2 also appears at the outputs of unity-gain buffers $U3_a$ and $U3_b$.

U5 is a retriggerable single shot driven by the noise limiter i-f and pulse-detection circuit (described later). When a noise pulse is detected, U5 outputs a negative-going pulse which lasts for the duration of the noise pulse plus 5 milliseconds. This pulse causes the internal switch contacts of $U2_a$ and U4 to open and the internal contacts of $U2_b$ to close.

When the contacts of $U2_a$ and U4 open, capacitors C1 and C2 hold the voltage to which they were charged. This voltage is the plus and minus i-f signal envelope prior to the noise pulse. When the internal contact of $U2_b$ closes, diodes CR_3 and CR_4 are enabled and clamp the i-f signal at the input of buffer U1 to the envelope voltage that existed just prior to the noise impulse.

The advantages of this circuit over other automatic i-f noise limiter circuits are:

- The voltage across C1 and C2 closely follows the envelope of the i-f output because R2, C1 and R3, C2 time constants are short.
- Capacitors C1 and C2 are buffered and their voltage doesn't change during the clamping interval.
- The forward voltage drops across CR_1-CR_4 cancel. As a result, the noise pulse is clamped to the exact envelope of the i-f signal just before the noise event.
- The actual interval of clamping is determined by a noise i-f amplifier having its own AGC separate from the receiver i-f section.

This circuit is extremely effective on the woodpecker, and on narrow ignition-type impulse noise. In fact, its effectiveness improves with increasing noise amplitude, because i-f AGC swamping is eliminated.

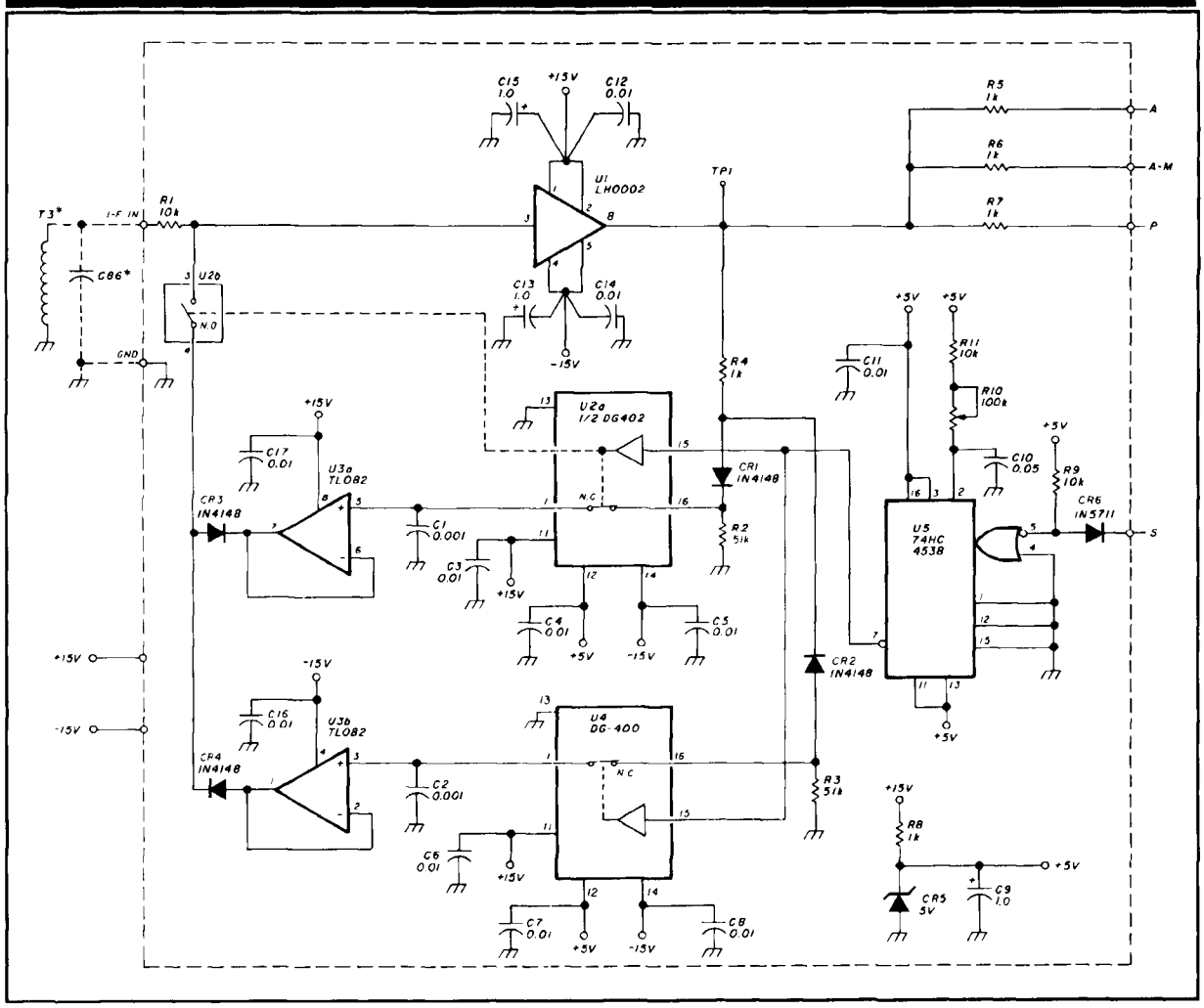
The method of generating the strobe pulses that feed U5 is very important in relation to the overall operation of the gated limiter. This will be discussed in more detail later when the noise limiter i-f circuit is described.

The 5-volt power for U5 is developed across the 5-volt zener, CR_5.

AM detector and AGC amplifier

AGC and AM detection are developed on the AM detector and AGC amplifier board (see **fig. 15**). AM

FIGURE 14



I-F buffer and gated noise limiter schematic.

detection is accomplished by rectifying the i-f output voltage with CR_1. The output is filtered by R2 and C2 and is buffered by op amp U1. Trimpot R3 provides an attenuation adjustment so that the AM output can be adjusted to the same amplitude as the SSB output from the product detector. The AM output from this board is routed to the front panel SSB/AM switch, S3 (fig. **1D**).

The AGC voltage is developed by rectifying the i-f output voltage with CR_2. The AGC voltage developed across C7 and R8 is buffered by U2. U2, CR_3, CR_4, and resistor R9 comprise a "super diode" circuit that eliminates the forward-voltage drop of CR_3.

Similarly $U3_a$, in conjunction with CR_5, CR_6, and R12 eliminate the forward-voltage drop of CR_6. This circuit also buffers the output of RF-gain control R99.

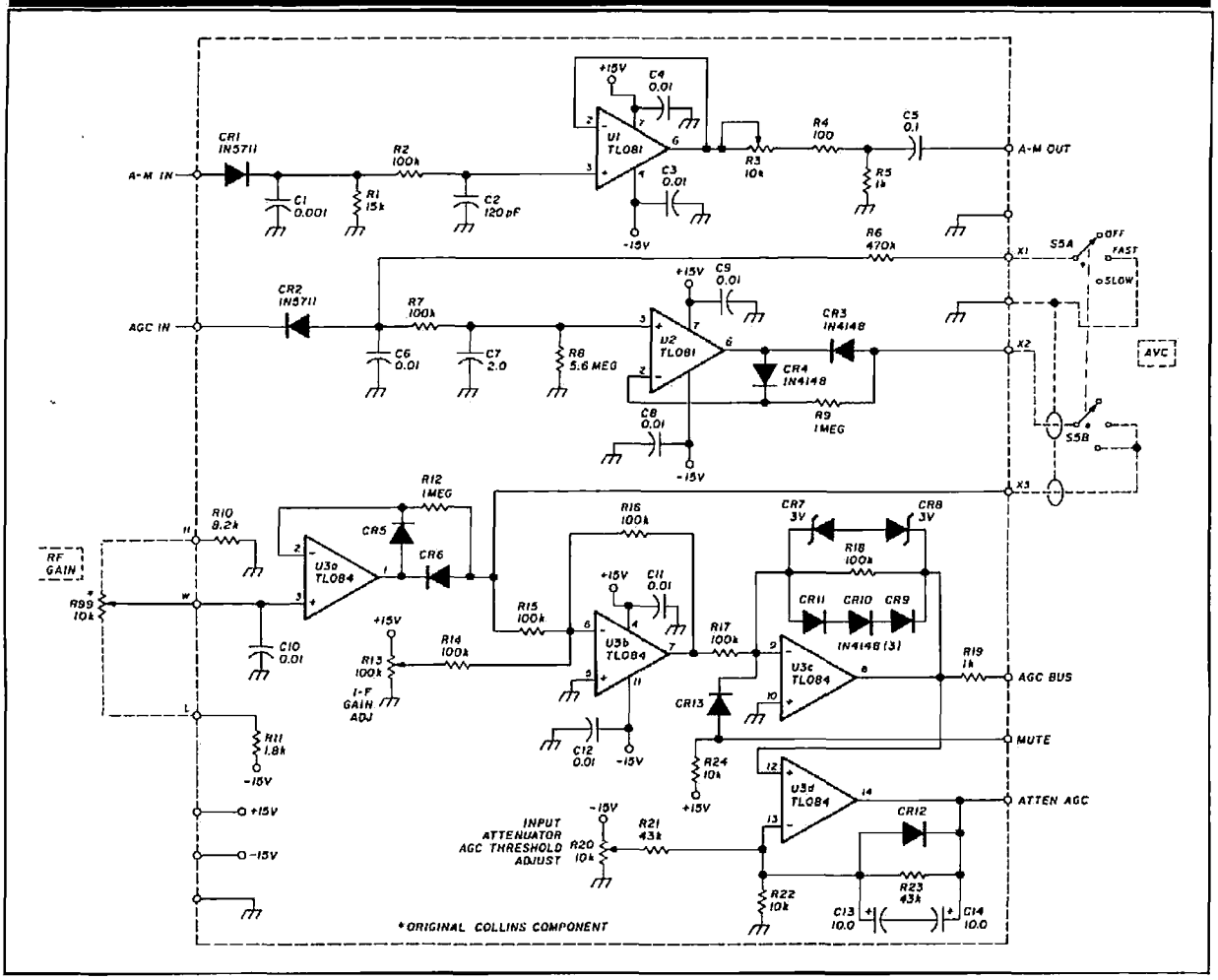
The anodes of CR_3 and CR_6 are connected together when AGC switch S5 is in its fast or slow position. The two diodes form a linear "OR" gate. The voltage developed at the anodes of CR_3 and CR_6 is equal to the output voltage at the RF-gain control wiper, R99, or to the AGC voltage developed at R8, whichever is the most negative. This voltage controls the RF and i-f gain by way of the AGC bus.

If front panel AGC switch S5 is placed in its off position, the connection between the anodes of CR_3 and CR_6 is opened. In this mode the receiver gain is controlled only by the setting of the RF-gain control.

CR_6's anode drives op amp $U3_b$. $U3_b$ is a level shifter that sets the quiescent "no signal" i-f gain through trimpot R13. R13 is adjusted for an i-f output amplitude of 15 volts peak-to-peak at test point 1 on the i-f buffer and gated limiter board (see fig. **14**).

$U3_c$ drives the AGC bus. CR_7 through CR_{11} clamp the output of $U3_c$ so that its voltage doesn't exceed approximately 3.5 volts, or drop below approximately −2.1 volts. The mute input at the anode of CR_{13} is normally

FIGURE 15



AM detector and AGC amplifier schematic.

SYNTHESIZED
SIGNAL GENERATOR



MADE IN USA

MODEL SG-100F $429.95 delivered

• Covers 100 MHz to 199.999 MHz in 1 kHz steps with thumbwheel dial • Accuracy +/– 1 part per 10 million at all frequencies • Internal FM adjustable from 0 to 100 kHz at a 1 kHz rate • External FM input accepts tones or voice • Spurs and noise at least 60 dB below carrier • Output adjustable from 5-500 mV at 50 Ohms • Operates on 12 Vdc @ ½ Amp • Available for immediate delivery • $429.95 delivered • Add-on accessories available to extend freq range, add infinite resolution, AM, and a precision 120 dB attenuator • Call or write for details • Phone in your order for fast COD shipment.

VANGUARD LABS 145

196-23 Jamaica Ave., Hollis, NY 11423
Phone: (718) 468-2720 Mon. thru Thu.

BLACK DACRON® POLYESTER ANTENNA ROPE

- UV-PROTECTED
- HIGH ABRASION RESISTANCE
- REQUIRES NO EXPENSIVE POTTING HEADS
- EASY TO TIE & UNTIE KNOTS
- EASY TO CUT WITH OUR HOT KNIFE
- SIZES: 3/32" 3/16" 5/16"
- SATISFIED CUSTOMERS DECLARE EXCELLENCE THROUGHOUT U.S.A.

LET US INTRODUCE OUR DACRON® ROPE TO YOU • SEND YOUR NAME AND ADDRESS AND WE'LL SEND YOU FREE SAMPLES OF EACH SIZE AND COMPLETE ORDERING INFORMATION.

Dealer Inquiries Invited

synthetic textiles, inc. 2472 EASTMAN AVE., BUILDING 21 VENTURA, CALIFORNIA 93003 (805) 658-7903

146

Electronic Repair Center

Servicing

Amateur **Commercial Radio**

The most complete repair facility on the East Coast.
Large parts inventory and factory authorized warranty service for Kenwood, Icom and Yaesu.

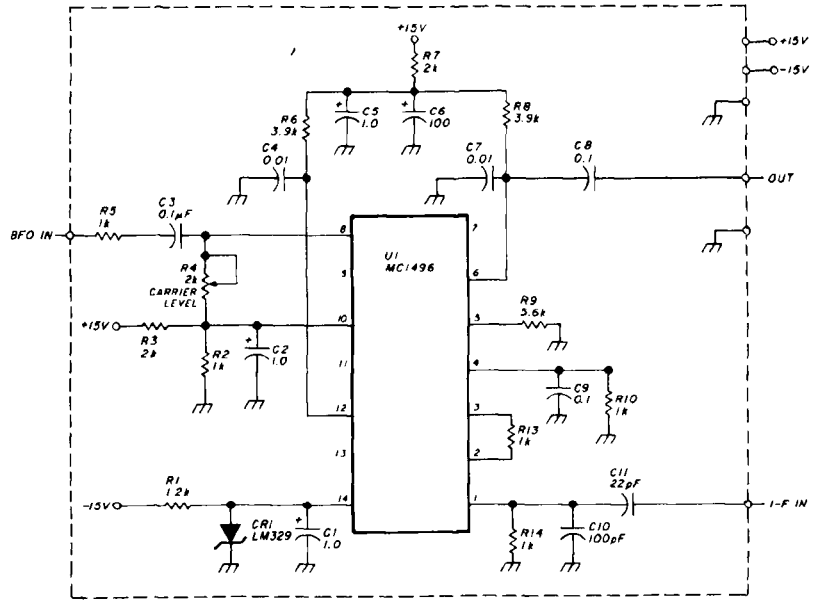
SEND US YOUR PROBLEMS

Servicing "Hams" for 30 years, no rig too old or new for us.

HAMTRONICS, INC.

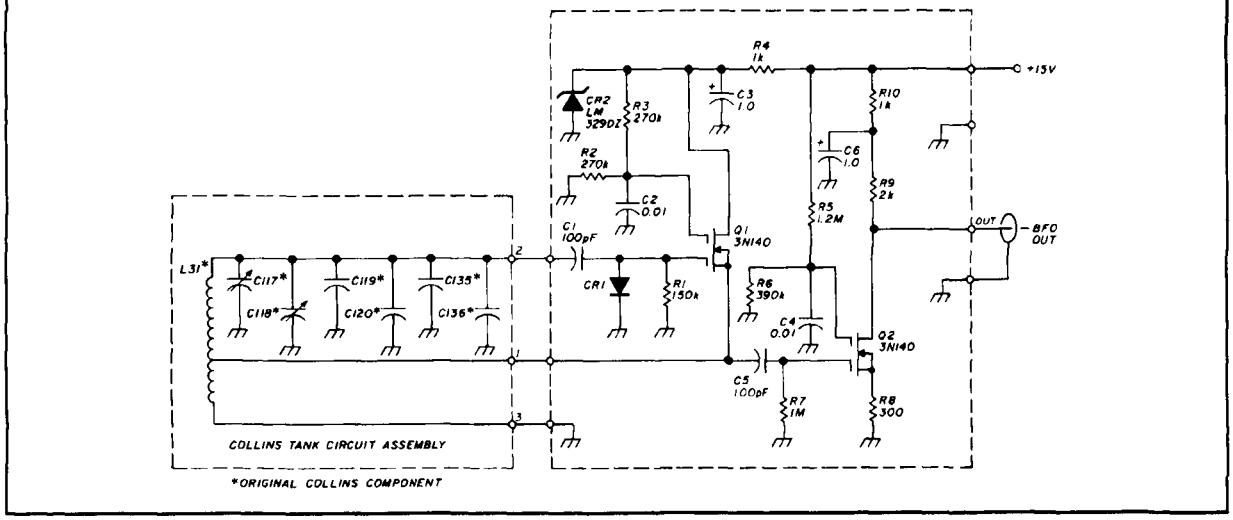
4033 Brownsville Road
Trevose, Pa. 19047
215-357-1400

FIGURE 16



Product detector schematic.

FIGURE 17



BFO oscillator and tank circuit assembly schematic.

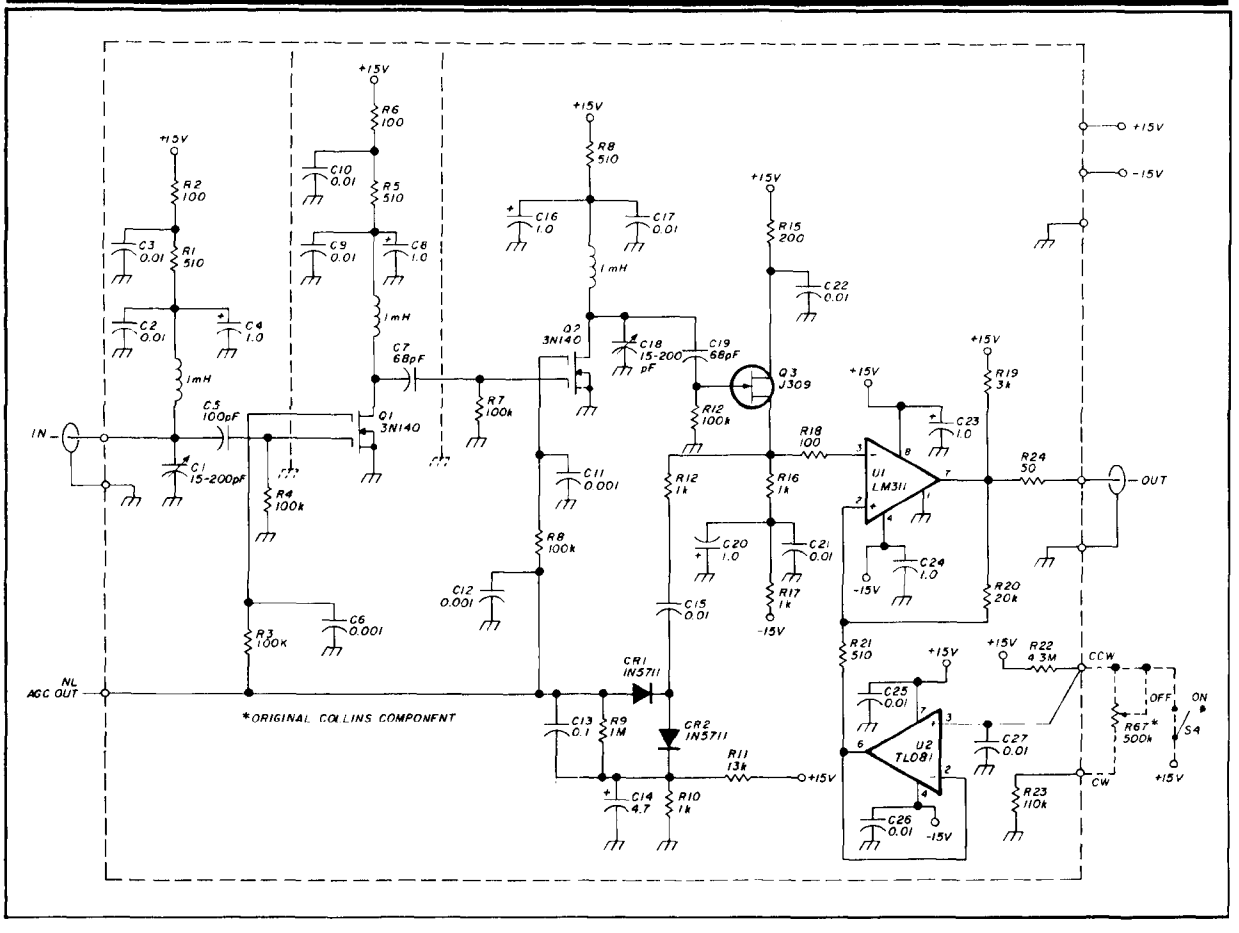
kept at ground potential so that CR_{13} is reverse biased. When the front panel AGC power switch is in the standby position, the mute input is opened and CR_{13} conducts. The conduction current through CR_{13} drives the output of $U3_c$ and the AGC bus to −2.1 volts; this effectively mutes the receiver.

The standby mode of the receiver may be overridden by shorting standby terminal 2 of the rear panel terminal strip E3 to ground (see fig. 1C).

The input attenuator has its own AGC voltage, which is developed at the output of $U3_d$. R20 is adjusted so that the attenuator AGC voltage is approximately 5 volts when a 100-μV signal is injected at the receiver input. This voltage decreases to about 2 volts for 100 mV input to the receiver.

CR_{12} in the feedback circuit of $U3_d$ prevents the input attenuator AGC voltage from going more negative than about −0.6 volt. C13 and C14 slow the output response

FIGURE 18



Noise limiter i-f and noise pulse detector schematic.

of $U3_d$ to keep the AGC bus from motorboating when the input attenuator is active.

Buffer amplifier U1 (fig. 14) also functions as an i-f limiter. This limiting effect is important; it prevents unpleasant noise and leading-edge signal bursts.

In the general case, the amplitude of fast-rising i-f signals and noise is limited by a fast-responding AGC. However, in this receiver design, I couldn't obtain a stable AGC loop and at the same time have an AGC attack time much faster than about 30 milliseconds. This occurs because of the delay introduced by the mechanical filters and experienced by the i-f signal as it responds to the effects of AGC.

The i-f limiting action of U1 limits the leading edge of fast-rising i-f signals and noise to an acceptable level during the time interval required for the AGC to operate. The overall effect is to make the AGC appear to have an attack time on the order of a few milliseconds.

Product detector

The product detector is shown in fig. 16. I used a Motorola MC1496 balanced modulator. This IC requires a lot of external components, but provides linear detection and little 455-kHz output component. The CW/SSB signal is taken from terminal 6 of U1, through C8. This output signal goes to the front panel AM/SSB switch, S3, as shown in fig. 1D.

The BFO output is attenuated by carrier-level trimpot R4. This pot is adjusted for a carrier level of 300 mV rms at U1, pin 8.

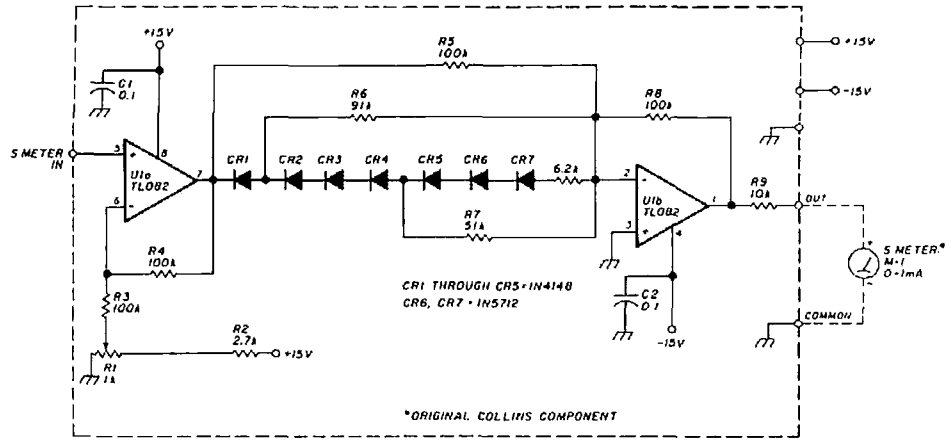
BFO

The BFO is comprised of the original BFO tuned-circuit assembly and the BFO board shown in fig. 1B. The BFO board is shown schematically in fig. 17. It's nearly identical to that used in the VFO described earlier.

The BFO has its own regulator comprised of voltage reference CR_2 and resistor R4. The 15-volt power is routed to the BFO through front panel AM/SSB switch, S3.

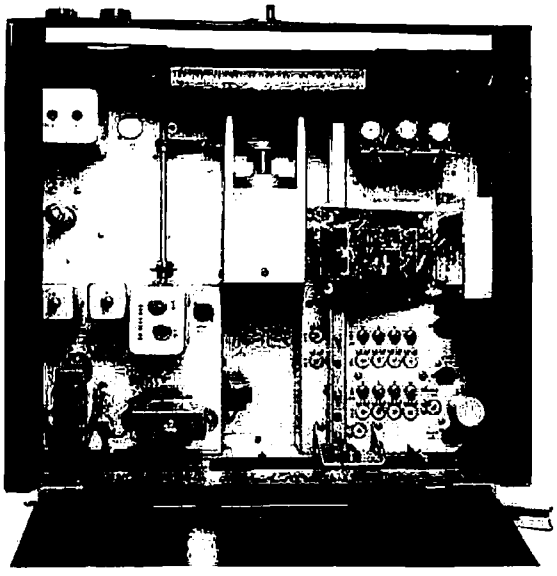
The stability of the BFO circuit is only slightly less than that of the VFO. At constant temperature, its drift is less than 10 Hz in the first minute after turn-on, and about 10 Hz per hour thereafter.

FIGURE 19



S-meter driver schematic.

PHOTO C



Top inside view showing exposed noise limiter, i-f circuit, and added 3.1-kHz mechanical filter.

Noise limiter i-f and noise pulse detector

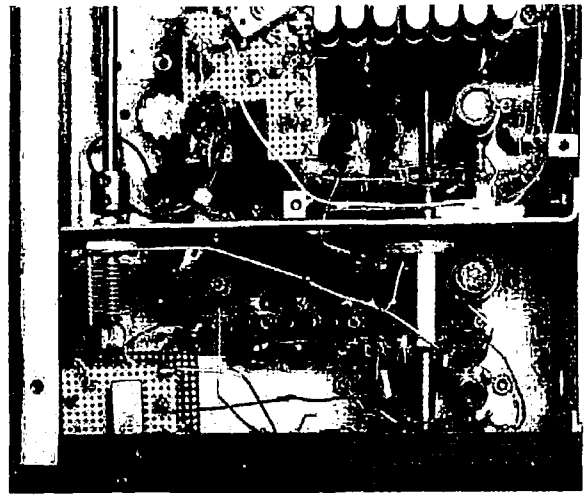
As stated earlier, the gated noise limiter has its own separate i-f amplifier. This amplifier with the noise pulse detection circuit is enclosed in a small chassis located on the top deck of the receiver. The position of this chassis is shown in **Photos A, B and C. Photo C** shows the i-f chassis opened with the i-f circuitry exposed.

The noise limiter i-f and the pulse detection circuit are shown in **fig. 18.** The interconnection of this circuit with the front panel **noise limiter** switch, S4; control pot R67; i-f buffer and gated-noise limiter board; and the i-f amplifier are shown in the circuit diagram of **fig. 1C.**

Q1 and Q2 and their associated circuits comprise the i-f amplifier. Q3 is a unity-gain buffer between the output of the last i-f stage and the AGC and pulse-detection circuit. CR_1 and CR_2 make up the AGC rectifier. AGC voltage is developed across C13 and applied to the second gate of Q1 and Q2. AGC voltage is also applied to the first stage of the noise limiter i-f, which is located on i-f amplifier board 1 (see **fig. 10**).

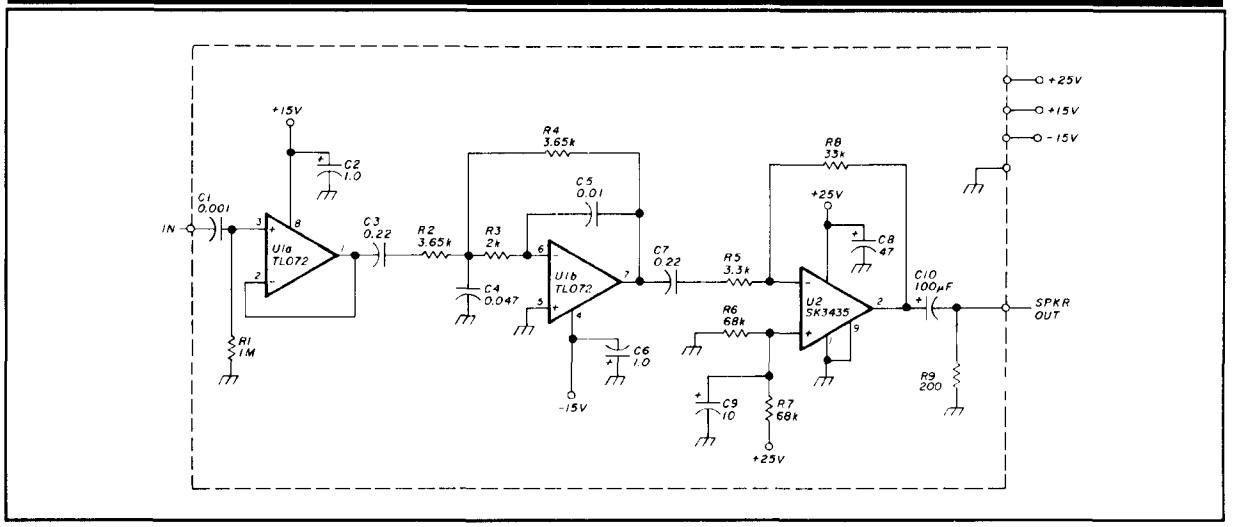
Noise pulse detection is accomplished by U1 and reference-voltage buffer U2. This circuitry functions as follows:

PHOTO D



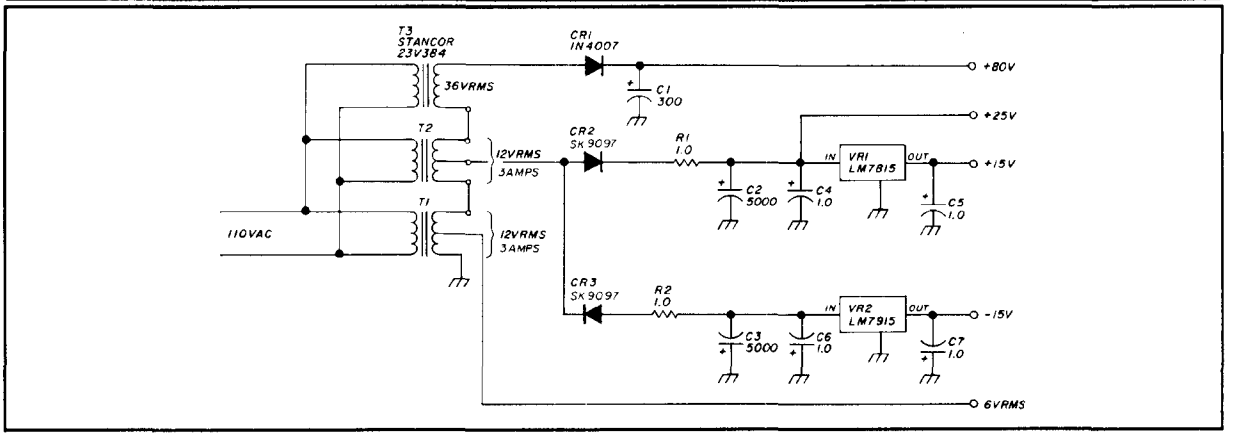
Partial bottom view showing location of switch S-1-G, input attenuator board, crystal-calibrator board, and oscillator board.

FIGURE 20



Audio amplifier schematic.

FIGURE 21



Power supply schematic.

• A variable threshold voltage is developed across front-panel noise limiter control R67 and is applied to the noninverting input of unity-gain buffer U2.

• Threshold voltage at the output of U2 is applied to the noninverting input of U1 through R21. R20 and R21 provide hysteresis, so that the comparator switches cleanly.

• The output of U1 goes to zero for the duration of any half cycle of the i-f signal that exceeds the threshold voltage developed at the output of U2.

The output signal from U1 is routed to U5 in the i-f buffer and gated noise limiter, (**fig. 14**). Because this single shot is retriggerable, it doesn't complete its time out until 5 milliseconds after the last pulse enters.

S-meter driver board

The voltage developed by the AGC bus of the solid-state receiver isn't compatible with the scale on the face of the S meter. I didn't want to change the appearance of the receiver by making a new face. My only choice was to make some type of nonlinear circuit that would match the meter face to the solid-state receiver's AGC bus voltage. This is the circuit on the S-meter driver board in **fig. 19**.

$U1_a$ of this circuit is driven from the AGC bus, as shown in **fig. 1C**. Trimpot R1 on the S-meter driver board adjusts the zero offset of the S meter. R1 is adjusted so that the S meter reads zero for 0.5 microvolts of RF input to the receiver. The resistor-diode network made up of CR_1 through CR_7 and resistors R5, R6, and R7 comprise what is equivalent to a nonlinear resistor having high resistance at low negative voltages, and the converse.

This circuit provides excellent S-meter calibration throughout its range. An S9 meter reading in the original receiver corresponded to a 100-mV signal. I prefer

256 μV for an S9 reading and calibrated the meter accordingly.

Audio amplifier

The output of the product and AM detectors is routed through the front panel switch and from there through front panel af gain control R62 (see fig. 1D). The af gain-control output is routed to the audio-amplifier circuits shown in fig. 20.

The first audio stage, $U1_a$, is a unity-gain buffer whose output drives a unity-gain, two-pole active low-pass filter. This filter consists of $U1_b$ and its associated components. $U1_b$ drives an SK3435 amplifier module. Feedback resistors R5 and R8 give the amplifier a gain of 10. The module is powered from the unregulated 25-volt supply and has a power capability in excess of 5 watts. The 3-db bandwidth of the audio amplifier is 300 to 3000 Hz. The output of the audio stages feeds the speaker terminals and headphone jack as shown in fig. 1D.

Power supply

The power supply is shown in fig. 21. T1 and T2 are Radio Shack filament transformers having a 12.6-volt center-tapped secondary rated at 3A. Transformer T3 has a 36-volt secondary rated at 60 mA. The 80-volt unregulated output is obtained by connecting all of the secondaries in series. The input to the rectifiers for the $\pm$ 15 volt three-terminal regulators comes from the center tap of T2. Simple half-wave rectifier circuits are used for all the supplies. The 6-volt AC power for the panel lamps is taken from the center tap of transformer T1.

VFO alignment

I did a lot of experimenting with the permeability tuned section of the VFO while designing this oscillator. By the time I had decided on the design described above, VFO linearity wasn't what it was supposed to be.

I recalibrated the oscillator by measuring the VFO output frequency with a frequency counter, then plotted the output frequency as a function of dial setting. This plot gave a clear indication of those areas on the dial where the VFO's frequency needed to be increased or decreased.

I first adjusted the trimming stud of L200 to get the end points of the VFO dial lined up. I then opened the hermetic enclosure and adjusted the PTO tracking washers to restore the linearity between the end points. I had to repeat this process a number of times before the VFO linearity and alignment were restored.

The next time I make this modification, I won't change the location of the tap on L201 of the VFO. I suspect that the drift characteristics will be almost as good, and I'm sure a lot less effort will be necessary in the realignment of the VFO after the modifications are made.

General alignment

The balance of the alignment, with a few differences, can be done in the same order and way as that described in the 75A-4 operator's manual. The more important differences are listed as follows:

- When measuring i-f output amplitude, I made all my measurements with an oscilloscope connected through a probe to TP1 of the i-f buffer and gated limiter board, fig. 14.
- I adjusted the output of the band-select crystal oscillator to 5 volts peak-to-peak on all bands. This adjustment was made with the oscilloscope and probe through the 1-pF isolating test point on the band-select crystal oscillator board of fig. 6. The method of computing the crystal oscillator output amplitude was described in the band-select crystal oscillator section above.

Performance measurements

Comparative measurements of sensitivity, two-tone intermodulation distortion (IMD), and blocking were made using the methods and test setup described in Chapter 25 of the 1987 *ARRL Handbook*.

I used a Hewlett-Packard HP606A RF generator and a Boonton Radio Corporation 240A RF generator as the signal sources for these tests. Both of these generators have excellent precision attenuators. A Wavetek 5080.1 precision step attenuator, a Mini Circuits ZSC-2-1 hybrid combiner, and a Ballantine 323 true rms-reading voltmeter made up the balance of the test setup. A Tektronix 2235 100-MHz oscilloscope was used to verify all initial signal amplitudes before adding attenuation.

The combined drift of the BFO and VFO was measured by placing the receiver in the SSB mode and tuning in an external crystal calibrator. The audio-frequency output tone was measured for 8 hours, beginning from a cold start. The drift amounted to 13 Hz in the first minute, followed by a slow drift of about 26 Hz per hour. The slow drift stabilized after about 3 hours, giving a total drift of 91 Hz in that 3-hour period. Once stabilized, receiver drift was approximately $\pm$ 10 Hz per hour.

The major source of drift appears to be heat generated by the transformers located on the chassis near the BFO. This heat warms the chassis in the location of the BFO tuned-network assembly. A purist would probably mount these transformers on a heat sink above the chassis to improve the receiver's long-term drift. I haven't felt a need to do this because the drift that does occur seems innocuous.

Conclusion

As you might guess, this was a long-term project. I don't recommend that you take on this conversion unless you have another receiver to use in the meantime. A good oscilloscope and signal generator are essential.

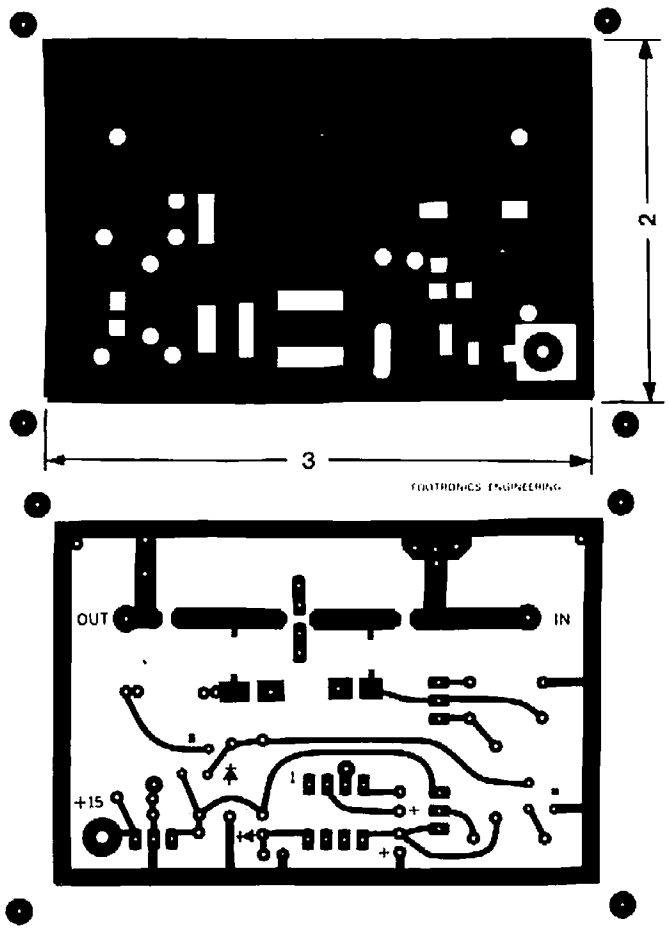
On the other hand, if you have the experience and equipment, you will find this a satisfying project — particularly if you have a 75A-4 that isn't being used because of circuit problems or lack of good tubes.

References

1. James R. Fisk, W1DTY, "Receiver Noise Figure, Sensitivity and Dynamic Range—What the Numbers Mean," *ham radio*, October 1975, page 8.
2. Ulrich L. Rohde, DJ2LR, "Optimum Design For High-Frequency Communications Receivers," *ham radio*, October 1976, page 10.

Bibliography

1. Sidney Kaiser, WB7CTW, "Measuring Receiver Dynamic Range," *ham radio*, November 1979, page 56.
2. Jan K. Moller, K6FM, "Understanding Performance Data of High-Frequency Receivers," *ham radio*, November 1981, page 30.
3. *The Radio Amateur's Handbook*, American Radio Relay League, Newington, Connecticut.



PC board layout for groundplane and trace sides, continued from page 60.

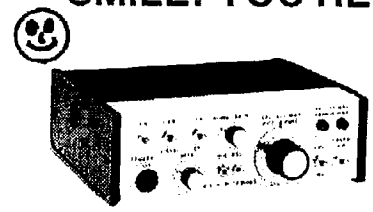
AND, THE WINNER IS...

Congratulations to Norman Roller, W6EDD, the winner of September's sweeps drawing and to Richard Measures, AG6K, author of September's most popular WEEKENDER — "An Easy-to-Build NiCd Pulse Charger. Both will receive a handheld radio. Want a chance to win? Just send us the evaluation card bound into this issue to enter for November's drawing, or submit a WEEKENDER project. Who knows; the next winner could be you!

Many thanks to all of you who've been supporting us during this time of change. Your insightful letters, comments on the evalution cards, and manuscript submissions will all play a part in creating the best *HAM RADIO* ever. Keep'em coming!

AMATEUR TELEVISION

SMILE! YOU'RE ON TV



Only $299

Designed and built in the USA Value + Quality from over 25years in ATV...W6ORG

With our all in one box TC70-1 70cm ATV Transceiver you can easily transmit and receive live action color and sound video just like broadcast TV. Use any home TV camera or VCR by plugging the composite video and audio into the front VHS 10 pin or rear phono jacks. Add 70cm antenna, coax, 13.8 Vdc and TV set and you are on the air...it's that easy!

TC70-1 has >1 watt p.e.p. with one xtal on 439.25, 434.0 or 426.25 MHz, runs on 12-14 Vdc @ .5A, and hot GaAsfet downconverter tunes whole 420-450 MHz band down to ch3. Shielded cabinet only 7x7x2.5". Transmitters sold only to licensed amateurs, for legal purposes, verified in the latest Callbook or with copy of license sent with order.

Call or write now for our complete ATV catalog including downconverters, transceivers, linear amps, and antennas for the 70, 33, & 23cm bands.

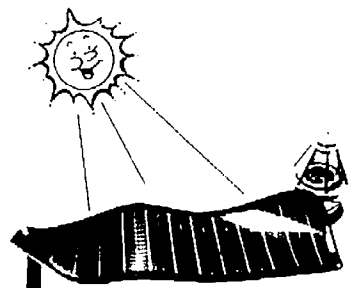
(818) 447-4565 m-f 8am-5:30pm pst. Visa, MC, COD

P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006

Tom (W6ORG)
Maryann (WB6YSS)

137

LET THE SUN DO THE WORK



- Charge batteries on stored machinery
- Light your tent
- Run fans
- Run remote transmitters
- Light signs
- Pump water for your animals
- Power for your motor home
- Run your radio without batteries
- Light your home
- Yard lights
- Charge flashlight batteries
- Light your cabin
- Run electric fences
- Charge your boat battery
- Run appliances in your home
- Charge hand held radio batteries
- Fish shanty lights
- Charge your Camcorder battery pack

Electricity from the Sun with

SEVONICS ™
SolarSystems

ALSO: *OUTSTANDING* PRICES ON IBM XT COMPATIBLE SYSTEMS!

SHIPPING INFORMATION: PLEASE INCLUDE 10% OF ORDER FOR SHIPPING AND HANDLING CHARGES (MINIMUM $2.50, MAXIMUM $10). CANADIAN ORDERS, ADD $7.50 IN US FUNDS. MICHIGAN RESIDENTS ADD 4½% SALES TAX. FOR *FREE* FLYER, SEND 22¢ STAMP OR SASE.



HAL-TRONIX, INC. (313) 281-7773
12671 Dix-Toledo Hwy
P.O. Box 1101
Southgate, MI 48195

Hours
12:00 - 6:00 EST Mon-Sat

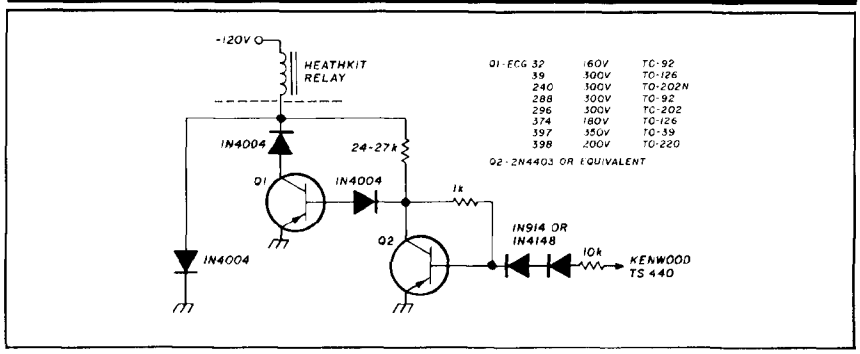
138

"HAL" HAROLD C. NOWLAND
W8ZXH



THE HAM NOTEBOOK

FIGURE 1



Schematic of the circuit used to interface from the +12Vdc keying output of the TS440S to the −120 volt bias supply of the Heathkit amplifier.

TS-440 interface for keying linears with high voltage biasing

I recently had a problem posed to me involving keying the relay of a Heathkit low-band linear from a Kenwood TS-440. The relay power in the linear is obtained from the −120 volt bias supply, and the transmit keying output from the Kenwood is +12 volts at 10 mA, maximum. The circuit below solved the problem. The key ingredient is the PNP driver transistor, which must be capable of handling at least 150 volts at about 250 mA. I've indicated several ECG types that meet the circuit requirements.

I'm sure others are running into the same or similar problem; I hope this circuit solves it!

Hugh Wells, W6WTU

Two simple 80-meter radiators for short and long skip

Getting the optimum performance from his equipment and antenna system is every ham's greatest desire — at least it should be! With this in mind, I want to share two simple but efficient radiators I've used during my 27 years in Amateur Radio.

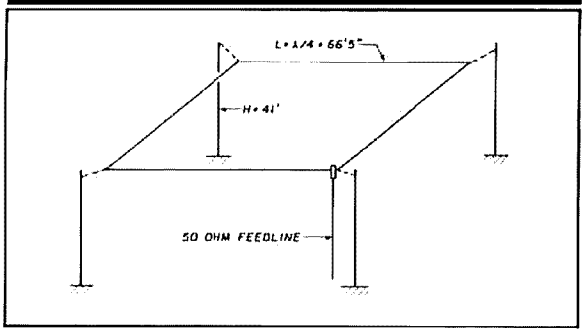
The first is a high-angle radiator, the second a low-angle radiator. The first is for contests, local round tables, and other local communications. It produces a strong signal because it's really a two-element antenna. This is because the earth appears as a reflector to the antenna when the antenna is mounted at the proper height. On-the-air comparative reports were made between the "lazy loop" mounted at approximately 25 feet and an 80-meter dipole mounted higher. Both receive and transmit reports consistently favored the loop.

The lazy loop construction is very basic (see fig. **1**). The total length of the loop is approximately one wavelength. Because the loop is actually square, each side is 66′ 5″ for a total wire length of 265′ 8″. The optimum height above ground should be in the neighborhood of 0.15 wavelength or 41′. Because of the effect of the ground on the antenna, the feed impedance is between 50 and 60 ohms. You should have no problems feeding the antenna directly with 50-ohm coax; however, you can use a balun if you wish. The loop can be constructed from copper wire of 16 AWG and up.

The second antenna, known as the "delta loop," provides exceptional low-angle radiation, which is useful for working DX. Construction again is very straightforward; you use a suitable gauge of copper wire cut to approximately 270′ in length. Provided the antenna is laid out as shown in fig. **2**, the feed impedance will be close to 50 ohms, allowing a direct feed with 50-ohm coax. Some of the pluses of this antenna are:

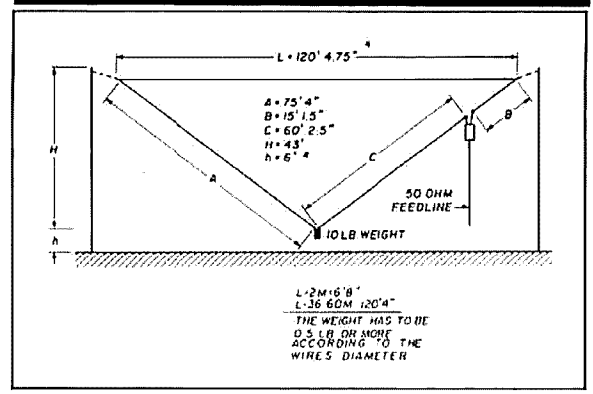
- Will fit anywhere a full-size 80 meter dipole will.
- Can be physically lower than an 80 meter dipole, and still perform as well or better.
- Can be fed directly with 50-ohm coax.

FIGURE 1



Full-wave horizontal loop with dimensions. This antenna is an excellent high-angle radiator and should be very useful for local communications.

FIGURE 2



Inverted Delta Loop for 80 meters. This antenna provides a good low angle of radiation and is excellent for Dxing.

So if you're tired of that old 80-meter dipole that just won't perform the way you want it to, here are two veteran antenna designs which will provide many hours of pleasant operating.

Sever Diaconu, YO4WU

Article G

Make the most of your general coverage transceiver with *Monitoring Times*!

Every month Monitoring Times brings everything you need to make the most of your general coverage transceiver: the latest information on international broadcasting schedules, frequency listings, international DX reports, propagation charts, and tips on how to hear the rare stations. Monitoring Times also keeps you up to date on government, military, police and fire networks, as well as tips on monitoring everything from air-to-ground and ship-to-shore signals to radioteletype, facsimile and space communications.

ORDER YOUR SUBSCRIPTION TODAY before another issue goes by. In the U.S., 1 year, $18; foreign and Canada, 1 year, $26. For a sample issue, send $2 (foreign, send 5 IRCs). For MC/VISA orders ($15 minimum), call 1-704-837-9200.

MONITORING TIMES

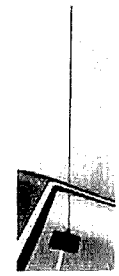
Your authoritative source, every month.

P.O. Box 98 A
Brasstown, N.C. 28902

135

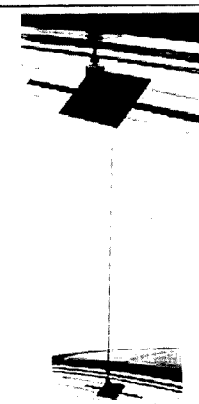
Look at our MOBILE MARK™ "ON WINDOW" Line

VHF (140-175)
- *No Hole*
- *Easy to Mount*
- *Rugged*
- *Superior Performance*
- *Radiator Snaps On and Off*
- *Competitively Priced*



UHF (420-520)
- *3 db gain*
- *No Hole*
- *Easy to Mount*
- *Rugged*
- *Superior Performance*
- *Radiator Snaps On and Off*
- *Competitively Priced*

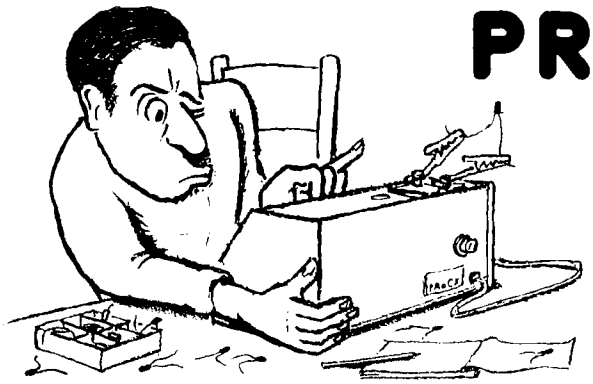
MODEL OW 3-150
140-174 MHz
MODEL OW 3-220
210-250 MHz
- *3 db gain*
- *No Hole*
- *Easy to Mount*
- *Rugged*
- *Superior Performance*
- *Swivel Vertical Adjustment*
- *Radiator Removal Without Loss of Vertical Adjustment*
- *Competitively Priced*



MOBILE MARK, INC.
COMMUNICATIONS ANTENNAS
3900-B River Road
Schiller Park, IL 60176
312-671-6690

brings imagination and innovation to antennas . . . . . and has been since 1948 !!

136



PRACTICALLY SPEAKING

Joe Carr, K4IPV

An overview of operational amplifiers: part 1

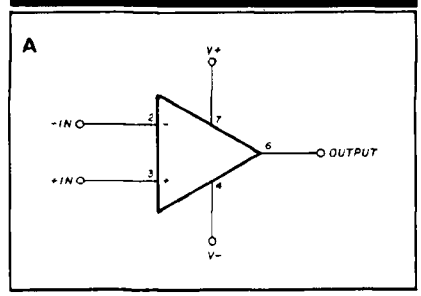
This month's topic is a discussion of the basics of operational amplifiers and other linear IC devices. Because the role of these devices is so great in radio communications equipment and circuits, it's important to understand them. Op-amps can be used for audio applications, in electronic measurement instruments, and in control circuits.

Operational amplifiers

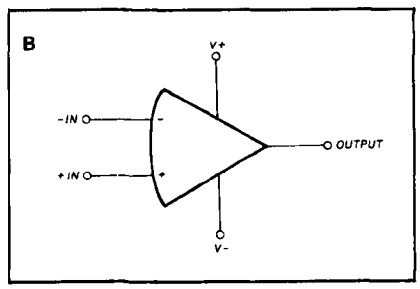
Figure **1A** shows the usual circuit symbol of the op amp. An alternate symbol is shown in fig. **1B**. (Burr-Brown and some ARRL literature use the alternate symbol.) This symbol is technically the "correct" one to use. It uses a curved back to which the input leads are attached. However, the version shown in fig. **1A** is used almost universally, even though it is the generic amplifier symbol, and could denote any amplifier stage — including the operational amplifier. Because it's the industry standard, I'll use the symbol in fig. **1A** here.

Note the pin-outs for the amplifiers in fig. **1**. The pin numbers given are for the 741 device, but have become something of an industry standard. There are two input connections, two power supply connections, and one output connection. There is no "ground" or common connection. The signal common is taken from the power supply common line. More on this in a moment.

FIGURE 1



Standard op-amp symbol. The pin outs are "industry standard" 741-family and fit a large number of different devices.



'Official" symbol used in some catalogs and ARRL publications.

The two power supply connections are V+ and V−. The V+ supply is positive with respect to common; the V− is negative. The range for these voltages is typically ±4 volts to ±18 volts, although a number of examples exist with wider (or slightly different) voltage ranges. A GE RCA CA-3140 BiMOS device, for example, operates at potentials up to ±22 volts for V− and V+, while certain "low-power" or "micropower" op amps operate down to ±1.5 volts DC.

In addition to the absolute voltage limits, there are sometimes relative limitations. For example, older 741 devices have a 30-volt limit for the voltage defined by the expression [(V+)−(V−)], even though each V− and V+ can be as high as 18 volts. As a result, if V+ is +18 volts, then V− must be not greater than −12 volts in order that the differential not be greater than 30 volts [(+18)−(−12) = +30 volts].

The selection of power supply voltages might also depend on the maximum anticipated output voltage. If the amplifier is being designed for use with an analog-to-digital converter that has an input voltage range of −10 to +10 volts input, then I certainly want the output of the amplifier to be capable of achieving those values. But there is a limit on how high the output voltage can reach; that limit is a function of the power supply voltage. In general, the limitation is based on the number of PN junctions between the output terminal on the IC and each power supply terminal. Each PN junction has a 0.7-volt drop which must be accounted for. If there are four PN junctions between the output terminal and the V+ power supply terminal, for

example, then the maximum allowable output voltage will be [(V+)−(4 × 0.7)] volts, or 2.8 volts lower than V+. When I want the output terminal to swing to +10 volts, the absolute minimum V+ power supply voltage will be 10 + 2.8 volts, or +12.8 volts DC. Obviously, a +12 volt DC power supply won't work in this case. In general, ordinary bipolar transistor op amps (like the 741) require a supply voltage 2 to 4.5 volts higher than the maximum required output voltage, but must also remain within the V+ and V− constraints of the device. Some BiMOS and BiFET devices are available in which the maximum output signal voltage can be as low as 0.5 volts below the power supply potential.

Operational amplifier inputs and outputs

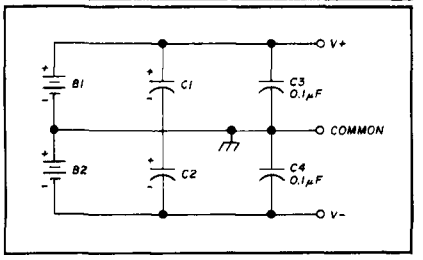
The two inputs for the operational amplifier form a "differential pair" because they are 180 degrees out of phase with each other. The *inverting* input (−) produces a 180-degree phase shift between the input signal and output signal (in other words, a positive-going input signal produces a negative-going output signal, and vice versa). The *noninverting* input (+) produces a zero-degree phase shift in the output signal. Since one input produces an in-phase output and the other produces an out-of-phase output, simultaneous application of the same voltage to both inputs produces a zero net output potential. I'll use this information in a later section to form the differential amplifier. The two inputs on the op amp offer a very high impedance, which is infinite in the ideal model. On paper, they are a perfect-voltage amplifier input.

The output of the operational amplifier is also suited to a perfect-voltage amplifier circuit. The output impedance of the typical op amp is usually quite low (10-100 ohms), so it forms a nearly perfect voltage source.

Operational amplifier DC power supplies

Figure 2 shows a model of the typical operational amplifier power supply.

FIGURE 2



DC power supplies for the op amp.

Either batteries or electronic power supplies operated from the AC power lines can be used. Recall that you have two different voltages in the op amp power supply: V+ and V−. Voltage V+ is supplied by B1; V− is supplied by B2. The common (or ground) connection is the junction between the two batteries. Normally, B1 and B2 will have the same voltage rating, but that is not a strict requirement unless other circuit considerations apply.

The capacitors shown in fig. 2 are used for decoupling, especially when multiple stages are fed from the same power supply. Capacitors C1 and C2 are normally 1-100 μF electrolytics, and are used for decoupling low-frequency signals. Capacitors C3 and C4 are used for decoupling higher frequency signals. You can't normally use the higher value C1/C2 for high-frequency signals because these are ordinarily electrolytic capacitors, which are ineffective at high frequencies. Fortunately, some new capacitors will operate to the frequencies covered by the gain-bandwidth product of most op amps.

The power supply common or "ground" connection is used as the zero-reference point for input and output signals on the operational amplifier. Whether the common is actually grounded or not depends upon circuit design considerations. In most cases it is grounded for the sake of simplicity.

In most applications, electronic power supplies used for B1 and B2 must be voltage regulated. Although there are certainly numerous applications where voltage-regulated DC power supplies are not strictly required, they are almost always good engineering practice. Because there are low-cost three-terminal fixed-voltage regulators now on the market, it's easy to obtain regulated power supplies.

The ideal operational amplifier

Before getting further into operational amplifier circuits, let's set the stage for a simplistic circuit analysis by discussing the properties of the "ideal" op amp. This ideal device has the following:

- Infinite open-loop gain
- Zero-output impedance
- Infinite input impedance
- Zero-noise contribution
- Infinite bandwidth
- Differential inputs which "stick together."

Let's define these properties and compare them with those found in practical IC operational amplifiers.

Infinite open-loop gain. This means that the voltage gain of the ideal operational amplifier in the open-loop (i.e., no feedback) configuration is infinite. Real op amps don't even approach the ideal, but are still good enough approximations to make the device function properly. The ability of practical op amps to approach the ideal depends on having extremely high open-loop gain, otherwise the equations behave badly. In practical devices, you'll find that the open-loop voltage gain (A_{vol}) will be 20,000 in low-cost devices, and well over 1,000,000 in premium ones.

Zero-output impedance. The operational amplifier is supposed to be a perfect-voltage amplifier, so it should offer an output impedance of zero. Real devices have output impedances of 10-100 ohms, with most being around 50.

Infinite input impedance. This parameter means that the input will neither sink nor source electrical current. Recall that input impedance is $Z = V_{in}/I_{in}$, so for input impedance to be infinite, I_{in} must be zero. In real operational amplifiers, the input current is non-zero. This is one of the primary differences between premium and low-cost devices. Low-cost amplifiers use

SEND FOR FREE 1988 CATALOG... 56 PAGES

★QUALITY PARTS ★DISCOUNT PRICES ★FAST SHIPPING

ALL ELECTRONICS CORP.

WE STOCK OVER 4,000 ITEMS... CALL OR WRITE FOR OUR FREE CATALOG OF PARTS!

RESISTORS • CAPACITORS • DIODES • CABLES • BRIDGE RECTIFIERS • CHOKE COILS • CRYSTALS • CRIMP CONNECTORS • LAMPS • HEAT SINKS • MOTORS • SUB MINIATURE D CONNECTORS • TRANSISTORS • IC'S • PROTO BOARDS • POTENTIOMETERS • POWER SUPPLIES • JACKS • PLUGS • SWITCHES • PERF BOARDS • FANS • FUSES • SHRINK TUBING • TIE WRAPS • TOOLS • KEYPADS • VIDEO ACCESSORIES • RELAYS • S.C.R.'S • TRANSFORMERS • TELEPHONE ACCESSORIES • RIBBON CABLE • CUT BREAKERS • VOLTAGE REGULATORS AND MANY OTHER ITEMS

TRANSISTORS

10 AMP SOLID STATE RELAYS

ELECTRICAL CONTROL

SWITCHES

MINIATURE TOGGLE SWITCHES

PIEZO WARNING DEVICE

SOUND ACTIVATED BOARD

24 VOLT D.C. SOLENOID

MINI PUSH BUTTON

XENON TUBE

NEW! STROBE KIT

SOUND & VIDEO MODULATOR

GRAB BAGS $1.00 EACH

ITT PUSH BUTTON

HALL EFFECT SWITCH

NICKEL-CAD (RECHARGEABLE) BATTERIES

WALL TRANSFORMERS

PROTO BOARD

FULL WAVE BRIDGE RECTIFIERS

10 AMP 200 P.I.V.

25 AMP RATING

N-CHANNEL MOSFET

WIDE BAND AMPLIFIER

LIGHT EMITTING DIODES (L.E.D.)

MAIL ORDERS TO:
ALL ELECTRONICS
P.O. BOX 567
VAN NUYS, CA 91408

TWX-5101010183
(ALL ELECTRONIC)

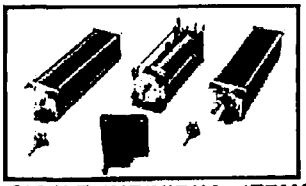
OUTSIDE THE U.S.A.
SEND $1.50 POSTAGE
FOR A CATALOG!!

TOLL FREE
800-826-5432
INFO: (818) 904-0524
FAX: (818)781-2653
MINIMUM ORDER $10.00
QUANTITIES LIMITED
CALIF. ADD SALES TAX
USA: $3.00 SHIPPING
FOREIGN ORDERS
INCLUDE SUFFICIENT
SHIPPING.
NO C.O.D.

STORES: LOS ANGELES 905 S. VERMONT AVE. LOS ANGELES, CA 90006 (213)380-8000 — VAN NUYS 8228 SEPULVEDA BLVD. VAN NUYS, CA 91411 (818)997-1806

✓ 133

1500 + WATT TRANSMATCH KIT $169.95



BASIC KIT: INDIVIDUAL ITEMS

1 - rotary inductor 28μh..... $59.00
2 - 6:1 ball drives.....$9.00 ea
1 - 0-100 turns counter.....$65.75
2 - variable capacitors
25-245 pf 4500 v.....$44.00 ea.

OPTIONS—
enclosure (pictured in Sept. 86 CQ). $64.00
4:1 balun kit.....$22.50
dials, terminals, chassis, ceramic standoffs, hardware, toroids, amp components, B&W coil stock, etc.

OTHER KITS

Article Reprints (refundable).....$1.50
G3RUH, PSK Packet Modem, Satl./Terrestrial $99.00
PC Board for above only, delivered.....$27.99
Ten-Tec Designer Cabinet for above.....$12.00
K9CW Memory Contest Keyer.....$109.00
Yaesu FRG-9600, .1 to 60 MHz Converter....$94.95
20m CW, 15w Transceiver (H.R. 6/87).....$159.95
50W 75M SSB XCVR.....$199.95

Factory Wired

New Tech DVK-100A (New Model).....$269.00
B & W PT-2500A Amp.....$1,670.00
B & W VS1500A Tuner.....$388.00
Amp Supply/Ameritron Linears.....CALL

Shipping Extra Unless Noted
Catalog $1.00

RADIOKIT • P.O. Box 973-H
Pelham, NH 03076 • (603) 635-2235

✓ 134

bipolar transistor input stages and have input bias and leakage currents of up to 1 or 2 milliamps to contend with. Certain others have the input currents in the nano- to picoamp range. The RCA BiMOS op amps (CA3130/RCA CA-3140, etc.) use MOSFET input transistors to produce an input impedance of 10^{12} ohms. For most practical purposes that impedance is "infinite."

Zero-noise contributio The noise referred to here is internal device-generated noise added to the signal. This is another difference between low-cost and premium devices. The low-cost amplifiers add considerabl "hiss" noise, making them unusable on low-signal applications.

Infinite bandwidth. This parameter means that there is no limit to the operating frequency of the device, which is patently absurd in the case of real operational amplifiers. Unconditionally stable, frequency-compensated devices like the 741 may have an upper frequency limit of only a few kilohertz, while other op amps operate to several megahertz. Only a few devices are available for the high HF or low VHF frequency ranges. They are usually labeled "video operational amplifiers," or something similar. Some devices with gain-bandwidth products that imply HF operation don't operate as op amps *per se*, but will work to some degree even though they don't operate in accordance with standard op amp rules and equations.

Differential inputs which "stick together." This property is essential to the simplified circuit analysis used. It's also used in some circuit applications, like "bridge audio." The property implies that a voltage applied to one input will also appear on the other. You must treat both inputs mathematically the same in this regard. If you apply a voltage to the noninverting input, then you must treat the inverting input as if it also sees that voltage. This statement is not merely some theoretical device used to make equations work. If you apply a real voltage to a real noninverting input, and then connect a real voltmeter to the inverting input, you will measure the same

age at that point. This point is very important, and I'll touch on it again next month when I deal with inverting and noninverting amplifiers.

Next month...

Next month I'll expand on the op amp theme and look at the three most basic circuit configurations: *inverting follower*, *unity gain noninverting follower*, and *noninverting follower with gain*. I'll derive the transfer equations, and display an interesting property of operational amplifiers — the property that makes them so easy to use.

This article is based on my new book: "IC User's Casebook," (Sams No. 22488, available from the *HAM RADIO* Bookstore for $12.95, plus $3.50 shipping and handling. I can be reached at POB 1099, Falls Church, Virginia 22041 and would like to have your comments and suggestions for this column.

Article H **HAM RADIO**

CIE Cleveland Institute of Electronics

1776 East 17th St., Cleveland, Ohio 44114

Accredited Member National Home Study Council

CIE is the world's largest independent study electronics school. We offer ten courses covering basic electronics to advanced digital and microprocessor technology. An Associate in Applied Science in Electronics Engineering Technology is also offered.

Study at home — no classes. Programs accredited and eligible for VA benefits.

CIE Cleveland Institute of Electronics
1776 East 17th St., Cleveland, Ohio 44114

YES! I want to get started. Send me my CIE school catalog including details about the Associate Degree program.

Print Name _____

Address _____ Apt. _____

City _____ State _____ Zip _____

Age _____ Area Code/Phone No. _____

Check box for G.I. Bulletin on Educational Benefits

☐ Veteran ☐ Active Duty MAIL TODAY!

✓ 131 AHR-07

WE SHIP WORLDWIDE

Barry Electronics Corp.

WORLD WIDE AMATEUR RADIO SINCE 1950

Your one source for all Radio Equipment!

For the best buys in town call: 212-925-7000

Los Precios Mas Bajos en Nueva York

KITTY SAYS: WE ARE NOW OPEN 7 DAYS A WEEK

Saturday & Sunday 10 to 5 P.M.

Monday-Friday 9 to 6:30 PM Thurs. to 8 PM

Come to Barry's for the best buys in town

Gobble Up Our Thanksgiving Savings

ONV Safety Bells-in stock

ICOM

YAESU

FT-767GX, FT-757GXII, FT-311 RM, FRG-8800, FT-736, FRG-9600, FT-711RH, FT-2700RH, FT 212/712RH.

KENWOOD

Antennas

SMART PATCH

PRIVATE PATCH IV Duplex 8000

Budwig ANT Products

FLUKE 77 Multimeter

NYE MBV-A 3 Kilowatt Tuner

VoCom/Mirage/Alinco Tokyo Hy-Power/TE SYSTEMS Amplifiers & 5/8 HT Gain Antennas IN STOCK

ALINCO ALD 24T

YAESU FTR-2410, Wilson

ICOM IC-RP 3010 (440 MHz)

ICOM IC-RP 1210 (1.2 GHz)

ICOM IC-RP 2210 (220 MHz)

MFJ-9898

Soldering Station, 48 Watts, $68

MICROLOG ART 1 Air Disk. SWL Morse Coach

Computer Interfaces Stocked MFJ-1270B MFJ-1274 MFJ-1224 AEA PK-88 MFJ-1278 PK-232 WEFAX

MOTOROLA AUTHORIZED DEALER

KACHINA COMMUNICATIONS DEALER

Ten-Tec Tuner 2298

Complete Butternut Antenna Inventory In Stock!

DIGITAL FREQUENCY COUNTERS

HEIL EQUIPMENT IN STOCK

METRON MA-1000 D STOCKED

SANGEAN Portable Shortwave Radios

EIMAC 3-500Z 572B, 6JS6C 12BY7A & 6146B

BENCHER PADDLES, BALUNS, LOW PASS FILTERS IN STOCK

AEA 144 MHz
AEA 220 MHz
AEA 440 MHz
ANTENNAS

BIRD Wattmeters & Elements In Stock

MIRAGE AMPLIFIERS
ASTRON POWER SUPPLIES

AMERITRON AUTHORIZED DEALER

MAIL ALL ORDERS TO BARRY ELECTRONICS CORP., 512 BROADWAY, NEW YORK CITY, NY 10012 (FOUR BLOCKS NORTH OF CANAL ST.)

New York City's LARGEST STOCKING HAM DEALER COMPLETE REPAIR LAB ON PREMISES

"Aqui Se Habla Espanol"

BARRY INTERNATIONAL TELEX 12 7670

MERCHANDISE TAKEN ON CONSIGNMENT FOR TOP PRICES

AUTHORIZED DISTS. MCKAY DYMEK FOR SHORTWAVE ANTENNAS & RECEIVERS

IRTILEX "Spring St. Station"

Subways BMT "Prince St. Station" IND-"F" Train Bwy. Station"

Bus: Broadway #6 to Spring St Path—9th St. 4th Ave. Station

We Stock: AEA, ARRL, Alpha, Ameco, Antenna Specialists, Astatic, Astron, B & K, B & W, Bencher, Bird, Butternut, CDE, CES, Communications Spec., Connectors, Cushcraft, Daiwa, Dentron, Diamond, Drake, Eimac, Heil Sound, Henry, Hustler (Newtronics), Hy Gain, Icom, KLM, Kantronics, Larsen, MFJ, J.W. Miller, Mirage, Newtronics, NyeViking, Palomar, RF Products, Radio Amateur Callbook, Saxton, Shure, Telex, Tempo, Ten-Tec, Tokyo Hi-Power, Tonna, TOWES, W2AU, Weber, Wilson, Yaesu Ham and Commercial Radios, Vocom, Whirlpike, Curtis, Tri-Ex, Wacom, Duplexers, Repeaters, Philips Dodge, Fanon Intercoms, Scanners, Crystals, Radio Publications, Uniden, Kenwood, Maxon, Metron, RFC, Amp Supply

WE NOW STOCK COMMERCIAL COMMUNICATIONS SYSTEMS

HAM DEALER INQUIRIES INVITED. PHONE IN YOUR ORDER & BE REIMBURSED

COMMERCIAL RADIOS stocked & serviced on premises.

Amateur Radio Courses Given On Our Premises, Call

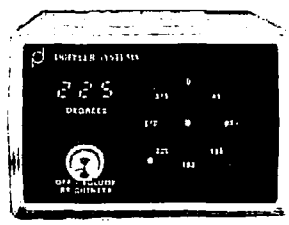
Export Orders Shipped Immediately. TELEX 12-7670

ALL SALES FINAL

Barry Electronics Commercial Radio Dept. offers the Best in two-way communications for Businesses, Municipalities, Civil Defense, Broadcasting Companies, Hospitals, etc. Sales and Service for all brands: Maxon, Yaesu, Icom, Tad, Octagon, Regency/Wilson, Midland, Standard, Uniden Shinway, Fujitus, Seas, Spillsbury, Neutec, etc. Call or write for information. 212-925-7000.

INTERFERENCE?

★ Interference Location
★ Stuck Microphones
★ Cable TV Leaks
★ Security Monitoring



★ VHF and UHF Coverage
★ Computer Interface
★ Speech Synthesizer
★ 12 VDC Operation

New Technology (patent pending) converts any VHF or UHF FM receiver into an advanced Doppler shift radio direction finder. Simply plug into receiver's antenna and external speaker jacks. Uses four omnidirectional antennas. Low noise, high sensitivity for weak signal detection. Call or write for full details and prices.

DOPPLER SYSTEMS, INC. P.O. Box 31819 Phoenix, AZ 85046 (602) 488-9755

✓ 132



Wideband Preamp 10-1000 Mhz

Dual GasFet low noise preamplifier for HF, UHF or VHF systems. Just perfect for the R-7000. Excellent for Spec Analyzers, Scanners, etc. Gain 20 Db +/- 1 DB, -3 Db at 2 & 1100 Mhz. 1 Db compression of >+10 Dbm. Intercept points >+45 Dbm. New shipped price of only $124.95. Pa. residents please add 6% state tax.

GTI Electronics
RD 1 BOX 272
Lehighton, Pa. 18235
717-386-4032

✓ 130

Mobiler's Dream!

Can you use a 6 dB stronger signal? Would 50% more bandwidth be helpful? Our SE-40 mobile antenna is the answer. Handles 600 watts for another 6 dB. SE-40, 40 - 10 meters; SE-75, 75 - 15 meters.

County Hunters Software

Designed by a top county hunter for county hunters. Works on all IBM type computers

R-4C Enhancements

Write for catalog

From the performance company:

Sherwood Engineering Inc.

1268 South Ogden Street, Denver, CO 80210
(303) 722-2257 Monday - Friday 9 A.M. - 5 P.M.

Sales, Service, Installations available from:

Design Electronics Ohio, KN8Z, Doc Sheller
(614) 836-5711 Days, (614) 836-3376 Evenings
LTA Industries, K3LR, Tim Duffy
(412) 528-9302 or (216) 533-7916

Sparky J-Antennas

• Install Fast • Extend Range • Improve Reception •

The Sparky J-Antenna is a flexible half wave radiator fed by two wavelengths of low loss coax through an efficient linear matching transformer. Sparky J's beat duckies, 1/4, & 5/8 wave antennas, need no ground plane. Low flat SWR curve gives edge to edge band coverage. Great portable--rolls up to fit in pocket. Completely assembled with BNC connector.

• Easily hidden • Effective indoors or out. • Money-back guarantee •

Available for every band from 28 to 440 MHz

$29.95 each Two for $55.00 Add $5 P & H

Intopack $1 by 1st class mail

AntennasWest
Box 50062-H, Provo, UT 84605 (801) 373-8425

✓ 106

(continued from page 9)

an article. The material in it was a rehash (for the most part) of an application written in *QST* (April 1984) and featured in the ARRL 1987 Handbook by a TRW engineer Fred Williams (credit was given in the bibliography). The article did go into more detail concerning phase noise and other problems associated with PLLs and how the DDS system overcame these problems. But, at least the Williams article published schematics and a parts list so "roll your own'ers" like me could play with it.

So please keep your standards high for the experimenter that your magazine addresses. Any articles that are a construction or any general theory content should have schematics and not a paragraph at the end saying, "send money." I do support an author offering to supply boards, "hard to find parts" or a complete kit for a fee, but at least require the article to supply enough information for a person to go from the article itself.

Please keep up the good work and I look forward to more informative issues.

Jeff Pierce Jr., WD4NMQ,
Kingsport, Tennessee 37663

Rave review!

Dear HR:

I will try to be succinct, but I gotta tell you.

My book shelves were getting overloaded with ham magazines so I decided to catalog those articles which were of interest to me and throw the rest away. I subscribe to two other popular ham magazines besides *HAM RADIO*.

After throwing away eighty percent of the other two as having no continuing interest, I then looked at the *HAM RADIO* file. I hadn't realized it before, but after going through all of them, I found an article of continuing interest in each one of them. Although *HAM RADIO* did not contribute to my house cleaning efforts I did end up with more room to hold future issues.

As I was writing this letter the September issue of *HAM RADIO* arrived. All I can say is — WOW — you have outdone yourself.

As a ham who built his first radio over 60 years ago from *Popular Mechanics* magazine, first transmitter from *Radio News*, and has been licensed for fifty-five years, I have a magazine that helps me keep up-to-date on the latest technology.

Kenneth L. Freeland, W1ANF,
Raymond, New Hampshire 03077

All constructive criticism welcome

Dear HR:

I read the September, 1988 issue with trepidation. I thought of the old adage, "If it ain't broke, don't fix it," as I read the issue. I am for changes in the magazine to keep pace with the "technology and standards in the graphic arts field." I do take exception to this issue as a showcase of your efforts, however.

The new layout of articles as displayed by the easy-to-spot heavy bar denoting the figures was not used in the articles obviously set up before the (seeming last minute) decision to go with the new style. No reason came to mind to not follow through with the new style throughout the magazine.

I really applaud the inclusion of the reader service card back in he magazine, as well as the plastic bag.

I just thought I'd give you my thoughts as I finish reading the issue and they are still fresh on my mind. Keep up the good magazine! and GOOD LUCK!

Richard Herndon, K5FNI,
Austin, Texas 78757-2424

We thought we'd give you some of the new and some of the old as a comparison. Glad you like our new style! Ed.

A round of applause

Dear HR:

I wanted to express my applause to the crew for some great graphics creating a fresh, exciting new look to *HAM RADIO*! It is the best face-lift HR has had since I've seen the publication.

Ed Buffington, WB1AMU,
Tustin, California 92681-3946



DX FORECASTER

Garth Stonehocker, KØRYW

WINTER DX SEASON

November through February is the winter DX season. Less ionization occurs because the D and E regions of the ionosphere receive less energy from the sun in the Northern Hemisphere. Attenuation results from signal energy being absorbed by ions in the D region (35-50 miles or 60-80 km above the earth) where your path crosses the D region. On any propagation path, absorption increases with the number of transits of the D region, and varies inversely with frequency. So in working DX, it pays to use the higher frequency bands to obtain more distance per hop (resulting in fewer transits) and less signal loss. But you can't always count on this; signals traveling a high-latitude path may be poor for several days at a time. This is known as the winter anomaly.

Along with lower signal attenuation, QRN decreases as fewer local thunderstorms pass through. As the large thunderstorm areas near the equator move farther south, their noise decreases by about 6-8 dB. This is particularly noticeable on the 160, 80, and 40-meter bands.

Even though ion production in the D, E, and lower F regions is less, ions are better able to diffuse and drift upward along the geomagnetic field lines into the F region. The F layer is the major factor in defining the maximum usable frequency (MUF) and the maximum on each side of the geomagnetic equator (see my October 1983 column). These maximums, which are reached most evenings at about 2200 local time, eliminate one whole earth bounce and its accompanying double-D region transits for one-long-hop propagation — real DXing.

Another advantage during the winter season is the increased stability of signal strengths resulting from the decrease in the number and intensity of geomagnetic field disturbances. This is attributable to the eccentricity of the earth's orbit. When the earth is closer to the sun, the solar flux pressure on the magnetosphere surrounding the earth tends to hold the magnetosphere steadier. So, the geomagnetic field is least disturbed during November and December, and there is less variation of the magnitude and direction of the geomagnetic field lines in a minute's time. Consequently, there are fewer periods of instability during the month, and better DXing.

Last-minute forecast

The higher frequency bands, 10-30 meters, are expected to be best during the third and fourth weeks of the month. During these days the solar flux should be highest and give good openings to the south, particularly in late evening and if a geomagnetic disturbance should occur to enhance the opening. Look for enhancement around November 5th, 15th, 22nd, and 31st. On the lower bands during these days look for lower MUFs, particularly during the night on east-west paths to Europe and Japan. These decreases may amount to 20 percent on the third night. Listen for DX openings from unusual QTHs also. Otherwise the lower bands are expected to be the best during the first and last weeks. Thanksgiving weekend (CQWW) is expected to have good openings on the higher bands and good nighttime conditions as well.

The Taurids meteor showers will occur from October 26th to November 22nd, with a maximum count of ten per hour from the 3rd through the 10th of November. Lunar perigee is on the 20th and a full moon falls on the 23rd.

Band-by-band summary

Ten and 12 meters, the highest day-only DX bands, are nearest the MUF for Southern Hemisphere paths. They will be open most days during the 3 to 5-hour period after local noon for the solar flux available this November. These bands open on paths toward the east and close toward the west. The paths are up to 4000 km (2400 miles) in single-hop length and, on occasion, double that during evening transequatorial openings.

Fifteen meters, a day-only DX band open most of each day, has lower signal strengths and greater multipath variability than 10 and 12 meters. It will be best when the MUF is resting just above this band, until it drops below it (a transition period that occurs after sunrise and just before sunset). Transequatorial openings will occur, with distances similar to 10 and 12 meters.

Twenty, 30, and 40 meters are both daytime and nighttime DX bands. Twenty is the maximum usable band for DX in the northern directions during the day. In combination with 30 meters, it provides nighttime paths for the day-only bands. Forty meters becomes the main over-the-pole DX daytime band, with some hours covered by 30 meters. This path and east-west paths may be affected by 10-20 dB of anomalous absorption during a few days of the month.

Eighty and 160 meters, the night-only DX bands, exhibit short-skip propagation during daylight hours, then lengthen at dusk. These bands follow the darkness path, opening to the east just before local sunset, swinging more to the north-south near midnight, and ending up in the Pacific areas for a few hours before dawn. Remember the DX window of 3790 to 3800.

Article I

WESTERN USA

GMT	PST	N	NE	E	SE	S	SW	W	NW
0000	4:00	20	30	20	10	12	12	10	15
0100	5:00	20	40	20	12	12	10	10	15
0200	6:00	20	40	20	12	12	10	12	15
0300	7:00	30	*40*	20	15	15	10	15	15
0400	8:00	30	*40*	*20*	15	15	12	20	20
0500	9:00	30	*40*	*20*	20	15	12	20	20
0000	10:00	30	*40*	*20*	20	20	15*	20	20
0700	11:00	30	*40*	*20*	*20*	20	15	20	20
0800	12:00	40	40*	*20*	*20*	20	15	20	20
0900	1:00	40	*40*	*20*	*20*	*20*	15	20	30
1000	2:00	*40*	*40*	*20*	*20*	*20*	15	*20*	*30*
1100	3:00	*40*	*40*	*20*	*20*	*30**	20	*20*	*30*
1200	4:00	*40*	*40*	15	*20*	*20*	*20*	*20*	*40*
1300	5:00	*40*	30	12	15	*20*	*20*	*20*	*40*
1400	6:00	*40*	20	12	15	20	*20*	*20*	*40*
1500	7:00	30	20	10	12	15	*20*	20	*40*
1600	8:00	30	20	10	12	15	*20*	20	*40*
1700	9:00	30	20	10	12	15	*20*	*20*	*40*
1800	10:00	40	20	10	10	15	15	20	30
1900	11:00	40	30	12	10	15	15	15	20
2000	12:00	40	30	12	10	12	15	15	20
2100	1:00	*40*	30	15	10	12	12	12	20
2200	2:00	*40*	30	15	10	12	12	12	15
2300	3:00	*40*	30	15	10	12	12	12	15

MID USA

MST	N	NE	E	SE	S	SW	W	NW	CST
5:00	30	30	20	12	12	10	10	15	8:00
6:00	20	40	20	12	12	10	12	15	7:00
7:00	30	40	20	15	15	12	15	20	8:00
8:00	30	40	*20*	15	15	12	15	20	9:00
9:00	30	*40*	*20*	20	15	15*	20	20	10:00
10:00	30	*40*	*20*	20	20	15	20	20	11:00
11:00	40	*40*	*20*	*20*	20	15	20	30	12:00
12:00	40	*40*	*20*	*20*	20	15	20	30	1:00
1:00	*40*	*40*	*20*	*20*	*20*	20	*20*	*30*	2:00
2:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*40*	3:00
3:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*40*	4:00
4:00	*40*	*40*	15	*20*	*30**	*20*	*20*	*40*	5:00
5:00	*40*	20	12	15	*20*	*20*	*20*	*40*	6:00
6:00	20	20	12	15	*20*	*20*	*20*	*40*	7:00
7:00	30	20	12	15	20	*20*	*20*	*40*	8:00
8:00	30	20	10	12	15	20	20	30	9:00
9:00	30	20	10	12	15	20	20*	20	10:00
10:00	30	20	10	10	15	15	20	20	11:00
11:00	30	20	10	10	15	15	20	20	12:00
12:00	40	20	10	10	12	15	15	20	1:00
1:00	40	30	12	10	12	15	15	20	2:00
2:00	*40*	30	12	10	12	12	12	20	3:00
3:00	*40*	30	15	10	12	12	12	15	4:00
4:00	*40*	30	15	12	12	10	10	15	5:00

EASTERN USA

EST	N	NE	E	SE	S	SW	W	NW
7:00	40	40	20	15	15	15	12	20
8:00	30	40	20	15	15	20	15	30
9:00	30	*40*	20	20	15	20	15	30
10:00	30	*40*	*20*	20	15	20	20	30
11:00	40	*40*	*20*	*20*	20	20	20	30
12:00	40	*40*	*20*	*20*	20	20	20	30
1:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*30*
2:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*40*
3:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*40*
4:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*40*
5:00	*40*	20	15	*20*	*20*	*20*	*20*	*40*
6:00	20	20	12	15	*30**	*20*	*20*	*40*
7:00	20	20	12	15	*20*	20	15	*40*
8:00	30	20	12	12	20	20	15	20
9:00	30	20	10	12	20	20	20	20
10:00	30	20	10	12	15	20	20	20
11:00	30	20	10	10	15	20	20	20
12:00	30	20	10	10	15	15	20	20
1:00	30	20	10	10	15	15	20	20
2:00	30	20	12	10	12	12	15	20
3:00	40	30	12	10	12	10	12	15
4:00	*40*	30	15	10	12	10	12	15
5:00	*40*	30	20	12	12*	10	10	15
8:00	*40*	30	20	12	12	12	10	20

NOVEMBER	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
WESTERN USA								
MID USA	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
EASTERN USA	ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

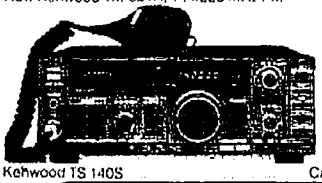
*Look at next higher band for possible openings.

MADISON SHOPPER

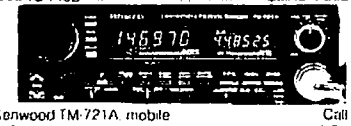
CALL FOR ORDERS
1 (800) 231-3057
1-713-520-7300 OR 1-713-520-0550
TEXAS ORDERS CALL COLLECT
FAX 1-713-771-7759

ALL ITEMS ARE GUARANTEED OR SALES PRICE REFUNDED

New Icom IC 781 — Trades wanted
Kenwood TH215A, TH25AT — Trade in your old HT
New Kenwood TM-621A, 144/220 MHz FM — Call



Kenwood TS 140S — Call for trade



New Kenwood TM-721A, mobile — Call
ICOM 28H/TTM — 410.00



Icom 761	2300.00
Shure 444D	56.95
HEIL BM10 Boom Mike, wired 8 pin	69.00
HEIL HM5 Desk Mike	62.00
Cushcraft 124-WB (146 MHz)	39.00
Butternut HF6VX, 80-10 vertical	125.00
Hustler G7-144	129.00
Larsen 2-meter on glass	49.95
Anteco 2M, 5/8, Mag. Mount, Comp	25.00
Van Gordon G5RV	44.00
Valor A85 mobile	79.00
Thousands of panel meters	3.95 up CALL
Aerovox 1000 pf/500 V feedthrough caps	1.95
Transformer 120 V Pri ,1050 V/1A (Sec #18 Wire)	50.00
100 mfd/450V Axial Cap	2.20
120 mfd/450V Axial Cap	3.00
Arista SWR Bridge 3-30 MHz	19.95
831SP PL259 Silverplate (Amphenol)	1.50
82-61 N Male (Amphenol)	3.50
82-202-1006 N Male (9913)	3.50
Double Female UHF	1.00
UG176 RG8X	each .40
Receiving tubes 50-90% off list price	
Santec Boom Mike/Headset (fits ICOM)	20.00
Rohn SA 25G 67 (67 inside arm)	..each 125.00



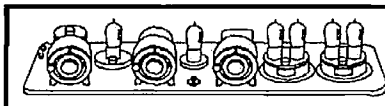
IC 781 — Call

USED EQUIPMENT
All equipment, used, clean, with 90 day warranty and 30 day trial. Six months full trade against new equipment. Sale price refunded if not satisfied
Call for latest used gear
(800) 231-3057

GNU PROD
TE Systems 2m Amp 30-160 watts GaAs fet — $229.00

POLICIES
Minimum order $10.00. Mastercard, VISA, or C.O.D. All prices FOB Houston, except as noted. Prices subject to change without notice. Items subject to prior sale. Call anytime to check the status of your order. Texas residents add sales tax. All items full factory warranty plus Madison warranty
Bird and Belden products in stock. Call today. ✓ 126

MADISON
Electronics Supply
3621 FANNIN
HOUSTON, TEXAS 77004
MasterCard VISA



IF YOU BUY, SELL OR COLLECT OLD RADIOS, YOU NEED...

ANTIQUE RADIO CLASSIFIED

Antique Radio's Largest-Circulation Monthly Magazine



FREE SAMPLE COPY!

Classifieds - Ads for Parts & Services
Articles - Auction Prices-Flea Market Info.
Also: Early TV, Ham Equip., Books, Telegraph, Art Deco, 40's & 50's Radios & more...
Free 20-word ad each month. Don't miss out!
6-Month Trial - $11.
1-Year: $19 ($28 by 1st Class)
Foreign by air – Canada: $30; Mexico: $28; Other: $55.
A.R.C., P.O. Box 2-A4, Carlisle, MA 01741
✓ 123

THE RF CONNECTION
"SPECIALIST IN RF CONNECTORS AND COAX"

Part No.	Description	Price
321-11054-3	BHC 2 PST 28 volt coaxial relay, Amphenol Insertion loss: 0 to 0.75GHz, 0.10dB Power rating: 0 to 0.5GHz, 100 watts CW, 2 kw peak Isolation: 0.1 GHz/45db, 0.2 GHz/40db, 0.4 GHz/35db	$25 used tested
83-822	PL-259 Teflon, Amphenol	1.50
PL-259/ST	UHF Male Silver Teflon, USA	1.50
UG-21D/U	N Male RG-8, 213, 214, Amphenol	2.95
UG-21B/U	N Male RG-8, 213, 214, Kings	4.00
9913/PIN	N Male Pin for 9913, 9086, 8214 fits UG-21D/U & UG-21B/U N's	1.50
UG-21U/9913	N Male for RG-8 with 9913 Pin	3.95
UG-21B/9913	N Male for RG-8 with 9913 Pin	4.75
UG-146/U	N Male to SO-239, Teflon USA	5.00
UG-83/U	Female to SO-239, Teflon USA	5.00

"THIS LIST REPRESENTS ONLY A FRACTION OF OUR HUGE INVENTORY"

THE R.F. CONNECTION
213 North Frederick Ave. #11
Gaithersburg, MD 20877
(301) 840-5477 ✓ 124
VISA/MASTERCARD: Add 4%
Prices Do Not Include Shipping

NEW!
The classic "Antenna Bible"
now in a thoroughly-revised, much-enlarged edition
ANTENNAS
2nd edition
by John Kraus, W8JK
Ohio State University

Covers both theory and its applications to practical systems. Over 1000 illustrations and nearly 600 worked examples and problems. Over 100 new topics. Complete with design formulas, tables and references

917 pages, hardcover. $51.95

Add $2.50 per book for shipping and handling U.S., $5.00 elsewhere.

CYGNUS-QUASAR BOOKS
P.O. Box 85, Powell, Ohio 43065
Tel. 614-548-7895
✓ 125

(continued from page 4)

also urged that studies continue to be done by qualified medical researchers on the effects of all forms of electromagnetic energy on the human body, and that we quantify what power densities are involved in common Amateur activities. Only with this knowledge can we be informed as to the *true* nature of the danger we face and minimize their impact.

How about you; are you concerned? Are you aware of any other studies that would be of interest? This is a problem that won't go away. It's better that we be knowledgeable about the hazards than to succumb to media hysteria, ignore the situation, or take little or no action and investigate further. Drop us a line and let us know what you think.

Craig Clark
N1ACH

*A bibliography of what we know has been published and is available from *HAM RADIO* for a SASE and twenty-five cents postage.

**Other concerned groups, include: Electric Power Research Institute, National Career Institute, NASA, Institute of Electrical and Electronics Engineers and ARRL.

***Unfortunately, an inexpensive RF power meter isn't available. How about one of you readers designing one for use in *HR* as a followup article.

SAY YOU SAW IT IN HAM RADIO



ELMER's NOTEBOOK

Tom McMullen, W1SL

SSB basics: generating the signal

The mode of choice for much of today's voice DX activity is single sideband, abbreviated SSB in literature, and shortened to "sideband" in the vernacular. It started out as a much larger mouthful: "single-sideband, suppressed carrier". Even the abbreviation "SSSC" didn't make it palatable to the glib of tongue, so SSB and sideband it became. It is one of the great leaps forward in radio communications and has made a great difference in our Amateur world.

Why?

The popularity of SSB, and the rapid growth of equipment that could handle this sometimes tricky mode, achieved two resounding successes almost simultaneously. First, because it eliminated the need to transmit an RF carrier, it eliminated that nerve-wracking, ear-splitting beat note that is created when two carriers are within a few Hz of each other. Second, it more than tripled our band space — three or more SSB stations can now use the same space that one amplitude-modulated (AM) signal used before.

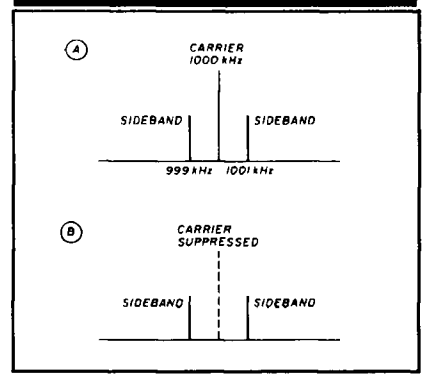
As if those two gains were not enough, it also contributed to the longevity of final amplifiers by reducing the power dissipated in just maintaining an RF carrier. In an AM signal of 100 watts, modulated 100 percent by a tone, half the power is in the RF carrier and the other half is shared between the two sidebands. When there is no modulation, as in pauses between words, the carrier is still there, making demands on the final amplifier. For a 100-watt carrier from a final amplifier that has perhaps 65 percent efficiency (most were much worse than that due to aging, design, or poor drive/loading), you can burn up close to 155 watts of DC just to get 100 watts of RF out, without modulation. Add modulation, and the power dissipation goes up along with it. Thus, it makes sense that if you can eliminate the steady drain of the RF carrier, your final should run cooler. By eliminating one of the sidebands, you can realize more economy in power and decrease the bandwidth required for the signal as well.

How

That sounds great, but how can you get rid of the carrier and one sideband?

To understand that, first take a look at the relationships between the carrier and the sidebands, as shown in **fig. 1A**. Let's assume an RF carrier at some nice round figure like 1 MHz, or 1000 kHz to make things easier to follow. To keep it easy, assume that the modulation is a sine wave at 1 kHz. This provides the classic profile of an AM signal, which has the carrier right in the middle between two sidebands. Because the frequencies both add and subtract, the product is a lower sideband at 999 kHz (1000-kHz carrier *minus* the 1-kHz modulation), and an upper sideband at 1001 kHz (1000-kHz carrier *plus* the 1-kHz modulation).

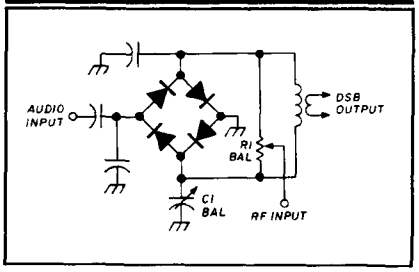
FIGURE 1



A normal AM carrier supports two sidebands, one below and one above, shown at A. Removing the carrier, as at B, leaves the sidebands, which are the elements that transmit information. After generating the sidebands, the carrier is no longer necessary for transmission.

Now, suppose you had a modulation circuit that could cause the carrier to cancel itself, leaving only the two sidebands, as in **fig. 1B**. Think about a basic bridge circuit for a moment — that very sensitive measuring circuit that allows only a difference between two voltages (signals) to appear at its output. Aha! The possibilities arise. Of course nobody wanted to call such a circuit a "bridge modulator," even if that's what it was — much too obvious. They're called "balanced modulators," and a sample circuit is shown in **fig. 2**. The carrier,

FIGURE 2



A simplified balanced modulator circuit. The RF carrier does not appear at the output, but the products of modulation — sidebands — do appear.

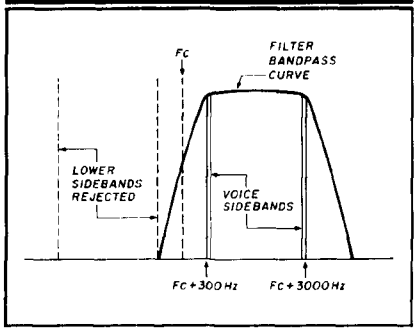
applied equally across the bridge, does not appear at the output. The modulation reacts with the carrier in the diodes (the necessary nonlinear element) and generates the sidebands. These appear at the output as upper and lower sidebands, just as in fig. 1B.

Many of the modern transmitters and transceivers used today have circuits more sophisticated than this, and some have a special integrated circuit that combines a balanced modulator and other functions on one chip. All have some means of adjusting for best carrier rejection (best bridge balance), either by varying a DC bias or by a variable capacitance to "tweak" the carrier for an exact phase shift or balance. The amount of carrier rejection can sometimes be very high in experimental circuits, but in practice it is in the range of 40-60 dB as measured at the output of the transmitter. That's still very good. A 100-watt carrier attenuated by 40 dB is only 0.0001 watt. That will cause far less interference than the original 100-watt AM earbuster did.

One sideband goes away

The next puzzler is how to get rid of one (and only one) sideband. There are RF and audio-phasing circuits that provide single-sideband output, but the bulk of today's transmitters rely on selective filters to pass one sideband and reject the other. Designers can do marvelous things with crystals, ceramics, and inductors, along with impedance matching and something I've recently talked about called "Q". The result is that a window can be placed right over a sideband, as shown in fig. 3. Actually, fig. 3 shows "sidebands," because it's hard to talk in a sine wave — voices are made up of many frequencies. This creates a range of sidebands, which must be transmitted intact if the guy at the other end is going to understand what you're saying. Communications equipment generally limits the frequencies in voice transmissions to 300-3000 Hz, so I've used that range in the illustration. The resulting output is simply treated as one "sideband" — the upper one is shown in fig. 3.

FIGURE 3



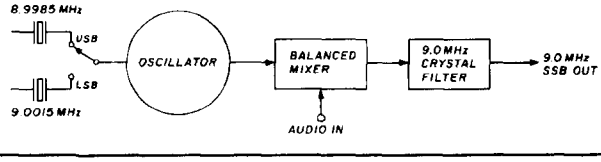
A crystal filter can be used to pass one sideband and reject the other. The suppressed RF carrier (F_c) is usually placed on one slope of the filter's response curve as shown in order to pass the band of frequencies in the sideband.

But, how do you...

Select between upper and lower sidebands? It can be done by using different filters, one for the upper and one for the lower. Just switch them in and out of the circuit as needed. Fortunately, there's an easier and less expensive way. Filters are made up of several elements and each one adds to the cost. Crystals, on the other hand, are simpler and less expensive. Just switch the crystals in the oscillator that generates the (suppressed) carrier. If you have two crystals with frequencies spaced just right, you'll have the upper sideband in the filter window when using one crystal, and the lower sideband in it when using the other. Neat!

Let's look at an example from a common scheme used in several past and present transmitters. Figure 4 will give you the idea. The oscillator has a switch to select between an 8.9985-MHz crystal and a 9.0015-MHz one. As shown, the 8.9985 crystal is selected and the sidebands are at 8.9970 and 9.0000 MHz. The filter, at 9.0000 MHz,

FIGURE 4



A simplified diagram of a system to select between upper and lower sideband by switching oscillator crystals. The 8.9985 MHz crystal provides upper sideband; the 9.0015 MHz one is for the lower sideband.

lets the upper sideband pass. Switch to the other crystal, 9.0015 MHz, and the sidebands are at 9.0000 and 9.0030 MHz. Again, the filter lets only one sideband through, in this case the lower one which is at 9.000 MHz. (These figures assume that an audio tone at 1500 Hz is used for modulation. With voice, this system will provide "sidebands" centered at 9.000 MHz.)

From here on, its just a matter of amplifying the few milliwatts that come out of the filter. This must be done carefully, using linear amplifiers to prevent signal distortion, which could cause splatter and irritate fellow hams. Tubes, transistors, integrated circuits, and "amplifier blocks" can be used here to build the power up to any level needed.

Oh, yes, there's one other thing. There is no Amateur band at 9.000 MHz, so a few conversions need to be performed to make the signal useful. Mixer circuits are used, and they can

vary from simple to complex. A balanced mixer (almost identical to the balanced modulator) is a good bet because it helps reject the local oscillator at the output, making life easier for following stages. For example, to get that 9.000-MHz sideband signal up to 28.5 MHz, you mix it with another signal at 19.5 MHz. The SSB signal is crystal controlled, so, in order to be able to move around on the band, the 19.5-MHz signal must be variable. A variable-frequency oscillator (VFO) at this frequency tends to be unstable, so the solution is to make the VFO operate at a much lower frequency, then mix it with a different crystal-controlled signal to provide stable output at 19.5 MHz (or other frequencies to use on different bands). VFOs and mixers are worthy of a greater discussion than I have space for this month, so I'll get back to them in a later issue.

Receiving SSB? That too is a subject worthy of a complete article, and I'll cover that in next month's column, along with an explanation of why SSB sounds so funny when you tune it in wrong.

HAM RADIO



A. Microwave Associates 10 GHz Gunnplexer. Two of these transceivers can form the heart of a 10 GHz communication system for voice, mcw, video or data transmission, not to mention mountaintop DXing! MA87141-1 (pair of 10 mW transceivers) $251.95. Higher power units (up to 200 mW) available. B. Microwave Associates 24 GHz Gunnplexer. Similar characteristics to 10 GHz unit. MA87820-4 (pair of 20 mW transceivers) $739.20. C. This support module is designed for use with the MA87141 and MA87820 and provides all of the circuitry for a full duplex audio transceive system. The board contains a low-noise, 30-MHz fm receiver, modulators for voice and mcw operation, Gunn diode regulator and varactor supply. Meter outputs are provided for monitoring received signal levels, discriminator output and varactor tuning voltage. RXMR30VD assembled and tested $119.95. D. Complete, ready to use communication system for voice or mcw operation. Ideal for repeater linking. A power supply capable of delivering 13 volts dc at 250 mA (for a 10 mW version), microphone, and headphone and/or loudspeaker are the only additional items needed for operation. The Gunnplexer can be removed for remote mounting to a tower or 2 or 4 foot parabolic antenna. TR10GA (10 GHz, 10 mW) $399.95. Higher power units available. TR24GA (24 GHz, 20 mW) $639.95. Also available: horn, 2 and 4 foot parabolic antennas, Gunn, varactor and detector diodes, search and lock systems, oscillator modules, waveguide, flanges, etc. Call or write for additional information. Let ARR take you higher with quality 10 and 24 GHz equipment!

Advanced Receiver Research

Box 1242 • Burlington CT 06013 • 203 582-9409

114

MAKE CIRCUIT BOARDS THE NEW, EASY WAY



WITH TEC-200 FILM

JUST 3 EASY STEPS:

- Copy circuit on TEC-200 film using any plain paper copier
- Iron film on to copper clad board
- Peel off film and etch

SATISFACTION GUARANTEED
convenient 8½ x 11 size

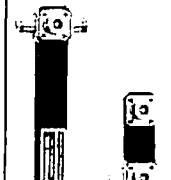
5-Sheets for $3.95
10 sheets only $5.95

add $1.25 postage — NY res. add sales tax

The MEADOWLAKE Corp.
DEPT. G, P.O. Box 497
Northport, New York 11768

115

VHF-UHF POWER DIVIDERS



RF power dividers provides the best way to feed in-phase 2 and 4 antenna arrays to maximize system gain and at the same time reduce losses to a minimum. Covering 144 thru 1296 MHz, this series of VHF/UHF power dividers are premier RF devices designed for a long service life with low SWR and broad operating bandwidth.

Extruded aluminum body with a durable enamel finish in addition to silicon sealing at connector flanges results in a ruggedized unit for all array installations. Available with N-type connectors only, these units are unconditionally guaranteed for 2 years.

MODEL	CONFIG.	PRICE
144-2P	(2 ports)	$54.00
144-4P	(4 ports)	$61.00
220-2P	(2 ports)	$53.00
220-4P	(4 ports)	$60.00
430-2P	(2 ports)	$51.00
430-4P	(4 ports)	$59.00
902-2P	(2 ports)	$51.00
902-4P	(4 ports)	$59.00
1296-2P	(2 ports)	$52.00
1296-4P	(4 ports)	$60.00

SHIPPING NOT INCLUDED

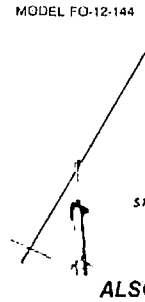
STRIDSBERG ENGINEERING, CO.
P.O. Box 7973 • Shreveport, LA 71107 • USA
Phone (318) 865-0523

116

PRESENTING

The K1FO 12 element 144 MHz YAGI

EME — TROPO — WEAK SIGNAL



ELECTRICAL SPECIFICATIONS

MECHANICAL SPECIFICATIONS

ALSO AVAILABLE

FO-16-220, FO-22-432, FO-25-432 and FO-33-432
STACKING FRAMES POWER DIVIDERS

We supply those hard to find parts for the home builder
Delrin insulators $12/100. Plated keepers $4/100. Stainless $10/100
Add $6 UPS $11 for single or pair of Antennas
$8 West of Mississippi

PA residents add 6% state sales tax

RUTLAND ARRAYS
1703 Warren Street • New Cumberland, PA 17070
(717) 774-5298 7-10 P.M. EST

Dealer inquiries invited

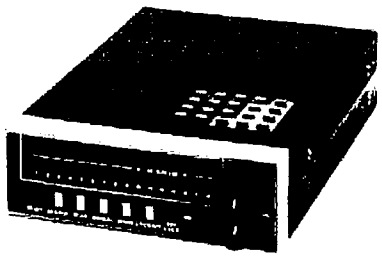
117



New mini mobile scanner from AOR

AOR, Ltd. of Tokyo, Japan has introduced a new miniature mobile scanner with frequency synthesized keyboard control. The new radio (model AR160) measures 1.5"x4.62"x6.5" and weighs 25 ounces. The receiver's frequency coverage is 29-52, 136-174, and 436-512 MHz.

The unit has a suggested retail price of $189; this includes a fused dc power cable, telescopic whip antenna, mobile mounting bracket with complete hardware, plus an ac-to-dc converter for indoor use.



Twenty front keys on the top access the onboard microcomputer which controls the unit. Light emitting diodes provide bright, read-at-a-glance channel information and verify frequencies through a count-off system. A battery retains memory in the event of power loss.

For further information contact Ace Communications, Monitor Division, 10707 East 106th Street, Indianapolis, Indiana 46256.

Circle #303 on Reader Service Card.

Radio Shack offers new catalogs

Radio Shack®, a division of Tandy Corporation, highlights its line of 1989 computer products in two new catalogs; the 1989 Tandy® Computer Catalog and Express Order Software Buyer's Guide.

The 52-page Tandy Computer Catalog features the new Tandy® 5000 MC, Tandy® 4000 LX, Tandy® 3000 NL, Tandy® 1000 TL and Tandy® 1000 SL computers, plus a complete line of printers, peripherals, accessories and software.

Tandy Corportion's Express Order Software Buyer's Guide is an 84-page catalog filled with programs for MS-DOS®, XENIX®, TRSDOS®, and Microsoft® Windows and MS®OS/2 operating systems as well as titles for Tandy's popular Color Computer family and portables.

MS-DOS software, at up to 35 percent off the manufacturer's suggested retail price, may be ordered either through Radio Shack's outlets nationwide or by calling 800-321-3133 for shipment directly to you.

The Radio Shack computer catalogs are available free of charge from Radio Shack Computer centers, Plus Computer Centers, and participating stores and dealers, or by writing Radio Shack Circulation Department, 300 One Tandy Center, Fort Worth, Texas 76102.

Circle #304 on Reader Service Card.

New *Aries-1*™

Aries-1™ developed by Ashton ITC, is a software program which integrates Amateur Radio equipment with an electronic Logbook (database). The program ties together multi-mode terminal units, computer capable transceivers, and a real time logging function.

In addition to controlling terminal units with simple key presses or mouse clicks (pressing the up or down arrow on the keyboard increases or decreases CW speed and RTTY baud rates) and providing for replaceable string parameters within pre-written text files (Log entries such as Name, City, Report, etc. may be automatically pulled from the on-line log and inserted into an existing text file during transmission through the Terminal Unit), *Aries-1* allows for simultaneous display of the TUs input/output on the same screen with the Logbook and Transceiver status.

The electronic Logbook features data search capability and automatic entry of date and time from the computer's clock. Frequency and mode are also automatically entered into the log when using a compatible transceiver. By clicking an optional mouse on the appropriate log entry, other data such as Station ID, City, State or Country, Name, etc. may be entered into the log from data received through a terminal unit without the need to re-type the information.

Aries-1 supports a Contest Mode which has instant dupe checking (displayed dupe information includes Frequency, mode, date/time, RST and optional exchange).

Other features include: the ability to run other programs from *Aries-1* while staying resident in memory; a capture buffer for selectively saving to disk input/output data from a terminal unit; searching and printing of log data by band, mode, country, etc.; updating QSO information within the log; and uploading and downloading of files through Packet, RTTY, etc.

Transceivers currently supported are Kenwood Model: TS-940S, 440S, 140S, 640S, 711A, and 811A (with appropriate Kenwood IC-10 Kit and IF-232C interface), and Icom models: IC-735, 761, 275, 375, 475, and 575 (with Icom CT-17 interface). Terminal units currently supported include the AEA PK-232, Heathkit HK-232, and Kantronics KAM all-mode units.

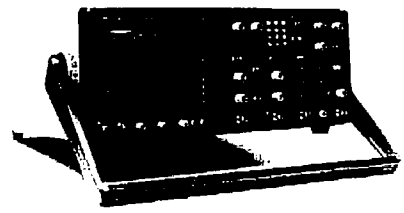
Aries-1 includes sample message files, a demo-log, and printed Users Guide. The program is available on 5-1/4 or 3-1/2-inch disks and runs on IBM PC/XT/AT.PS-2s or compatibles with at least 256K of memory. A serial port is required for connection to a compatible terminal unit or transceiver. A second serial port is necessary if you want simultaneous interface to both units. An optional mouse (Microsoft® bus version recommended) is also supported for even faster TU control and data entry. The price is $89.95, plus shipping and handling. For more details, contact Ashton ITC, PO Box 1067, VEstal New York 13851; 607-748-9028.

Circle #305 on Reader Service Card.

New digital storage oscilloscope

The new Philips PM 3320A Digital Storage Oscilloscope from John Fluke Mfg. Co., Inc., captures single events with its 200-mhz bandwidth, real-time sampling rate of 250 MS/s and 10-bit resolution.

Two acquisition modes are available to capture signal details exceeding preset limits — Save-on-Difference and Stop-on-Difference. They compare the incoming waveform with one in memory and record the new waveform (noting the time of capture) as soon as a difference due to jitter, spikes, or amplitude variation appears between the two signals. Another function, Absolute Min/Max, creates a historical record of a large number of traces and can be used to set the Save/Stop-on-Difference parameters. Other functions include digital filtering and the display of histograms, showing the amplitude distribution of a captured signal.



The PM 3320A DSO offers an on-board Fast Fourier Transform (FFT) option with an overview of the incoming signal's frequency spectrum. Other automatic measurement functions are: RMS voltage, percentage overshoot and preshoot for step functions, and continuously variable rise and fall times — including the two pre-set options of 10 to 90 percent and 20 to 80 percent of ECL applications. It also provides

(continued on page 122)



(continued from page 120)

automatic pulse width, duty cycle and phase measurements, division for ratio measurements, integration, and differentiation.

The Philips PM 3320A Digital Storage Oscilloscope suggested U.S. list price starts at $8,990. Allow six weeks for delivery. For more information in North America, write to John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206.

Circle #306 on Reader Service Card.

Hands-free cellular microphone

Shure Brothers Inc. has introduced the new Shure ClearVoice™ Hands-Free System. Designed to fit on the driver's seatbelt, it provides the cellular car phone user clear voice transmission while keeping both hands on the steering wheel.The system features a highly directional, supercardioid pickup pattern that makes the microphone 60 percent less sensitive to undesirable ambient noise such as that created by a defroster fan, radio, car engine, or even surrounding traffic.

The Shure ClearVoice System can be used with most cellular car phones equipped with hands-free circuitry. Installation takes about 30 minutes and can be done by any qualified cellular installer. The suggested retail price is $134.75.

For more information contact Shure Brothers Inc., 222 Hartrey Avenue, Evanston, Illinois 60202-3696.

Circle #307 on Reader Service Card.

RF/microwave prototyping boards

RF Prototype Systems introduces QUICK BOARDS for rapid evaluation and verification of designs. The double-sided, FR-4 board, with plated through holes, is useful when breadboarding commonly used circuits/devices.

Three boards are offered. The LPf1 is a general filter that accommodates several filter topologies up to seven sections, including low pass, high pass, and narrow band pass. It is sized to fit standard enclosures. The GB1, a gain block layout, provides 50-ohm interconection and dc bias for common MMIC amplifiers, like the Avantek MSA series. The TO81 is used for evaluating TO-8 voltage controlled oscillators and amplifiers and comes complete with holes for SMA connectors and power supply decoupling components.

For more information, contact RF Prototype Systems, 12730 Kestrel Street, San Diego, California 92129.

Circle #309 on Reader Service Card.

Improved electro-mechanical tool kit

Jensen has improved the popular JTK-79 Electro-Mechanical Tool Kit. Designed for the performance of a wide variety of electronic and mechanical repair tasks, the kit now contains a full 14-piece socket set, 7-piece jewelers screwdriver set, 10-piece hex key set, 4 screwdriver blades (two Phillips, two slotted), full-size handle, circuit tester, wire stripper/cutter, adjustable wrench, variety of pliers, and more.



The tools come in a compact 7 × 9 × 2″ padded zipper case with Velcro snap closure to hold an optional Beckman DM 73 Meter.

The JTK-79 is priced at $79.00. For more information and free catalog, write Jensen Tools Inc., 7815 S. 46th Street, Phoenix, Arizona 85044.

Circle #308 on Reader Service Card.

Digicom 64

Digicom 64 is a disk-based TNC emulator program for the Commodore 64 (or C128) computer. It is a public domain program written by hams in Germany that eliminates the need for a TNC and requires only an external modem for full packet radio operation.

The displayed modem circuit is based on the AM7910 chip; it supports both hf and VHF packet tones. No alignment is required. The circuit includes a "watchdog" timer as a failsafe for unattended operation and reed relay output. Power for the modem is taken directly from the C64; no external supply is necessary. The pc board is configured so that it may be plugged directly into the cassette port, or mounted remotely using a 6-conductor cable. Connectors for both configurations are included with each kit.

The complete parts kit with pc board is priced at $49.95, plus $2.50 shipping and handling. An assembled/tested unit is $79.95, plus 3.50 ship-

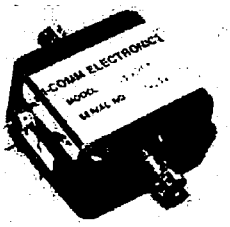
(continued on page 125)

5-1000 MHZ PREAMPLIFIERS

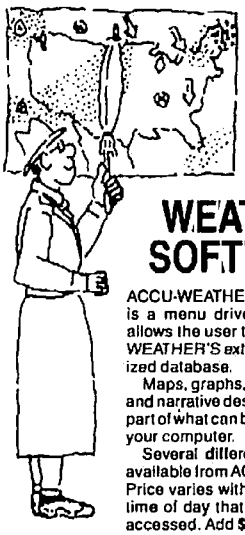
	NF	G	P(1dB)	$
WLA21m	3dB	13dB	8dBm	57
WLA22m	4	11	12	61
WLA23m	4	23	12	87
WLA24m	3	20	18	109

430/50MHZ CONVERTER

RCX431 .15μV 20dB 99



WILAM TECHNOLOGY, Div. of
WI-COMM ELECTRONICS INC.
P.O. Box 5174, MASSENA, N.Y. 13662
(315) 769-8334 ✓ 110



WEATHER SOFTWARE

ACCU-WEATHER FORECASTER is a menu driven program that allows the user to tap into ACCU-WEATHER'S extensive computerized database.

Maps, graphs, pictures, charts, and narrative descriptions are just part of what can be downloaded to your computer.

Several different services are available from ACCU-WEATHER. Price varies with the service and time of day that the computer is accessed. Add $3.50 for shipping and handling.

☐ MC-IBM $89.95
☐ MC-MAC $89.95
Please add $3.50 for shipping and handling

VISA

ham radio magazine BOOKSTORE
GREENVILLE, NH 03048 603-878-1441

U.S. AMATEUR RADIO MAILLISTS

Labels, floppy disks, CD-ROM, mag tape.
- Newly licensed hams
- All upgrades
- Updated each week

BUCKMASTER PUBLISHING
Route 3, Box 56
Mineral, Virginia 23117
703/894-5777 visa/mc 800/282-5628

✓ 112

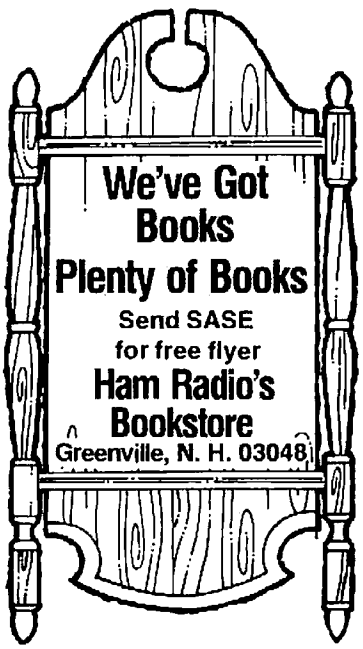
(continued from page 122)

ping and handling. Both include a program disk and documentation at no charge.

Program disks with documentation and blank printed circuit boards with construction details are also available.

For further information contact Barry Kutner, W2UP, 614-B Palmer Lane, Yardley, Pennsylvania 19067. Please enclose a SASE for reply.

Circle #310 on Reader Service Card.



Foreign Subscription Agents for Ham Radio Magazine

Ham Radio Austria
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio Belgium
Stereohouse
Brusselsesteenweg 416
B-9218 Gent
Belgium

Ham Radio Holland
Postbus 413
NL-7800 Al Emmen
Holland

Ham Radio Europe
Box 2064
S-194 02 Upplands Vasby
Sweden

Ham Radio France
SM Electronic
20 bis, Ave des Clarions
F-89000 Auxerre
France

Ham Radio Germany
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Canada
Send orders to
Ham Radio Magazine
Greenville, NH 03048 USA
Prices in Canadian funds
1 yr $41.85, 2 yrs $74.25
3 yrs $99.90

Ham Radio Italy
Via Maniago 15
I-20134 Milano
Italy

Ham Radio Japan
Katsumi Electronic Co., Ltd
27-5 Hegami
4 Chome, Ota-Ku
Tokyo 145, Japan
Telephone (03) 753-2405

Ham Radio Switzerland
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio England
c/o R.S.G.B.
Lambda House
Cranborne Road
Potters Bar
Herts EN6 3JW
England

Holland Radio
143 Greenway
Greenside, Johannesburg
Republic of South Africa

QuicKit™ G5RV, Loop, & Dipole Kits

Fast & Easy to Build
- Everything included
- Failsafe visual instructions
- No measuring/cutting
- Finish antenna in minutes

Quality Components
- Preseldered Amphenol PL259
- Kinkproof Superflex wire
- Fully insulated, wx sealed, no-corrode, low noise design

Fastest Antennas in the West
AntennasWest
(801) 373-8425 Box 50062-H, Provo, UT 84605

- Full Size G5RV dipole coverage 80-10 $34.95
- Half Size G5RV dipole coverage 40-10 $24.95
- Quarter Size G5RV dipole coverage 20-10 $19.95
- Marconi Adapter kit $ 4.95
- Antenna Launcher kit $14.95
- 200' Dacron 250# line $11.95
- Loops, dipoles, feedlines, etc.

Add $5 Shipping & Handling
Catalog $1 by 1st class mail

106



- Coming soon to a shack near you.
- Signals from space.
- Catch some free.
- We know how.
- You can too!
- Join AMSAT
- Free brochure for SASE

AMSAT
PO BOX 27
WASHINGTON, DC 20044

104

VISA ICOM MasterCard

VHF COMMUNICATIONS

915 North Main Street
Jamestown, New York 14701

INTRODUCING
W2DRZ VHF/UHF MODULES
NOW AVAILABLE
NOW AVAILABLE
900 MHz Transverter.....$299.00
Call for our special NOW

ICOM, AEA, LARSEN, VAN GORDEN, VIBROPLEX, NYE-VIKING, FALCON COMM, LEADING EDGE, ARRL PUBLICATIONS, KAGLO, HAMTRONICS, ETC.

Western New York's finest ... amateur radio dealer!
PH. (716)664-6345

105

DECEMBER 1988 $2.50

Season's Greetings

HAM RADIO



HAM RADIO

DECEMBER 1988

volume 21, number 12

T. H. Tenney, Jr., W1NLB
publisher
and editor-in-chief

Terry Northup
managing editor

Marty Durham, NB1H
technical editor

Robert D. Wilson, WA1TKH
consulting editor

Tom McMullen, W1SL
Joseph J. Schroeder, W9JUV
Alfred Wilson, W6NIF
associate editors

Susan Shorrock
production editor

Peggy Tenney, KA1QDG
copy editor

Beth McCormack
editorial assistant

editorial review board

Peter Bertini, K1ZJH
Forrest Gehrke, K2BT
Michael Gruchalla, P.E.
Bob Lewis, W2EBS
Mason Logan, K4MT
Vern Riportella, WA2LQQ
Ed Wetherhold, W3NQN

publishing staff

J. Craig Clark, Jr., N1ACH
assistant publisher

Henry S. Gallup, KA1RYG
director of advertising sales

Dorothy Sargent, KA1ZK
advertising production manager

Susan Shorrock
circulation manager

Therese Bourgault
circulation

Phil Alix, N1FPX
traffic manager

Maribeth Buchanan
HAM RADIO Bookstore

Hans Evers, PA0CX
cover

HAM RADIO Magazine is published monthly by Communications Technology, Inc. Greenville, New Hampshire 03048-0498 Telephone: 603-878-1441

subscription rates

United States:
one year, $22.95; two years, $38.95; three years, $49.95
Europe (via KLM air mail), $40.00
Canada, Japan, South Africa and other countries (via surface mail), one year, $31.00; two years, $55.00; three years, $74.00

All subscription orders payable in U.S. funds, via international postal money order or check drawn on U.S. bank

international subscription agents: page 118

Microfilm copies are available from Buckmaster Publishing Mineral, Virginia 23117

Cassette tapes of selected articles from *HAM RADIO* are available to the blind and physically handicapped from Recorded Periodicals, 919 Walnut Street, Philadelphia, Pennsylvania 19107

Copyright 1988 by Communications Technology, Inc. Title registered at U.S. Patent Office

Second-class postage paid at Greenville, New Hampshire 03048-0498 and at additional mailing offices
ISSN 0148-5989

Send change of address to *HAM RADIO* Greenville, New Hampshire 03048-0498

FEATURES

9 A Simple Direct Conversion Receiver
Rodney A. Kreuter, WA3ENK

19 The Weekender: Build This Simple L-C Checker
Jack Najork, W5FG

22 Ham Radio Techniques: New Zeland, Maui, and the Solar Cycle
Bill Orr, W6SAI

29 Structural Evaluation of Yagi Elements
Dick Weber, K5IU

51 Formatted Display of Packets Using KISS
Michael Pechura, WA8BXN

60 Decoding Data Signals
James A. Sanford, WB4GCS

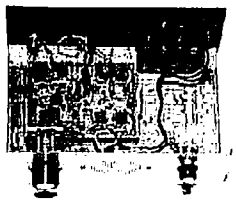
75 A Homebrew Tuning Dial
John Pivnichny, N2DCH

83 Practically Speaking: Overview of Operational Amplifiers: Part 2
Joe Carr, K4IPV

88 The Weekender: Get the Most from Your NiCds
W.C. Cloninger, Jr., K3OF

117 Elmer's Notebook: SSB Basics — Receiving the Signal
Tom McMullen, W1SL

Joe Reisert's column returns next month.



WA3ENK, page 9



THE WEEKENDER

W5FG, page 19
K3OF, page 88

See page 78 for the winners of October's handheld radio contest.

DEPARTMENTS

Backscatter	4	Short Circuits	107
Comments	6	DX Forecaster	110
Ham Notebook	26	Flea Market	118
New Products	59,70, 104, 125	Advertiser's Index	126
		Reader Service	126
Ham Mart	106		

Special thanks to Hans Evers, PA0CX, for all his great covers this year.

BACKSCATTER

A year of change at HAM RADIO.

What fosters a good relationship between a magazine and its readers? When I arrived here a little over a year ago, I asked myself that question. I decided that, first, I had to get to know you. I needed to find out what Amateur Radio, in general, and HAM RADIO Magazine, in particular, meant to you. I began reading letters, manuscripts, notes on renewal notices, old surveys — anything I could get my hands on. I met you at shows in Dayton and Boxborough. What I found was an incredibly diverse group of people — teachers, accountants, machinists, doctors, engineers, pilots, bank tellers, journalists, students, homemakers, retired persons (the list goes on and on) — all bound together by a love for Amateur Radio. And even within the hobby itself, there is something for everyone. Whether you build, contest, do public service work, or just like to get on the radio and talk, you can find a niche in this great hobby. I suddenly noticed antennas I'd never seen before in my neighbors' backyards, a ham radio comminications post at a local road race I ran in, callsigns on license plates — Amateur Radio is everywhere and a very important part of lots of lives!

How does HAM RADIO Magazine fit into your lives? There was a common theme in all your correspondence to us. You liked the technical flair of the magazine, but found many of the articles were dry, complicated, or just plain too long. You wanted more construction projects, weekenders, and shorter technical pieces that explained the theory behind the idea in a more concise fashion. But, you didn't want HAM RADIO to become "just another contest magazine." You liked what we were; you simply wanted some refinements.

After the Dayton Hamvention, the editorial staff got together to decide how to best meet your requests. In September we launched our first "new" HAM RADIO issue. We filled it with the kinds of articles you wanted to see (Weekenders, ham notes, projects, technical pieces), gave it a different look, and included evaluation cards for your comments. Your response to each new issue has been tremendous; it has given us a yardstick by which we can judge our performance. Without you, we could not have effected this change. With you, and your continued support, we will continue to grow.

Because our changes have been so well received, we'll carry them into the future. In the months to come you can look forward to pieces on ATV, digital voice, and new antenna designs. And, for you homebrew buffs, January brings our first construction issue.

Of course, our ability to deliver the kind of magazine you want to read depends not only on your constructive criticisms, but on the fine manuscripts you submit. You are our writers as well as our readers, and we'd love to help you share what you've built or learned with your fellow Amateurs. If you don't know how to get started, write for our author's guide; it's got lots of helpful hints. C'mon, what are you waiting for?

It's been a long year. A year of change — but positive change. You've been with us through it all. We thank you and look forward to a long happy relationship with you — our readers and friends.

Terry Northup
Managing Editor

P.S. Thought you'd like to know that I too have succumbed to the lure of Amateur Radio. I passed my Novice test and am waiting for my license to come. Hope to see you soon on the Novice bands!
KA1???

Correction: In our November editorial, "A potential danger," the National Career Institute was listed as a group concerned about the effects of electromagnetic radiation. The reference should have read National Cancer Institute. *Ed.*

Happy Holidays from all of us at Ham Radio



COMMENTS

Good news and bad news

Dear HR:

Just received the September 1988 issue of *HAM RADIO* magazine an hour ago. Naturally, I have not had time to go through it in great detail, but I like what I see and like it so much that I am willing to extend my subscription for another three years.

Now for the bad news. The printing job in my issue leaves much to be desired. Many of the pages have the material printed so close to the edge of the page that a slim portion of the text and advertising is cut off and missing. I assume this is a one-time problem.

Enclosed is my evaluation card. Keep Bill Orr's column coming. His writings are usually the first place to which I open your magazine. I have been a fan of his since the days of his antenna articles featuring Pendergast in the small-format CQ magazines.

Lee G. Andreas, N9BDL,
Lake Tomahawk, Wisconsin
54539-9500

Advice for the novice

Dear HR

Can't remember when I wrote a letter to the editor but Marty wrote an editorial (Reflections) in the August issue that I take exception to. He was commenting on the high cost of equipment to get the Novice started, and asking us to dig out the old stuff that is collecting dust to give them a start.

Have we forgotten that a one-tube crystal oscillator is a good CW transmitter? And, a two-tube regenerative receiver (or a transistor and op amp) make a compatible receiver?

We are doing an injustice to the young people when we try to train them to be applicance operators rather than giving them an introduction to the technical world and allowing them to enjoy communications with equipment they've constructed. Many of us have enjoyed careers as electronics engineers because we built our first equipment, and we built it because we could not afford the complete receivers and transmitters. If the beginners don't experience the pleasure of construction, how will they ever know?

If you really want to help the Novice, don't give them a radio, give them help in constructing a radio and a good antenna.

When the old timers get together, they don't talk about their first contacts without going into intricate detail about the design of their first hay-wired radio. Forty years from now, the Novice of today won't even remember which box he bought first.

Ted Hart, W5QJR, Melbourne,
Florida 32902

Handling traffic—a challenge

Dear HR

With regard to Mr. Harold P. Morgan, WD0P's letter in the July, "Comments", Ham Radio Magazine, I would like to say that I too am in complete agreement with Mr. Morgan. My situation is only somewhat different, for I am somewhat of a traffic handler.

Traffic is a challenge to me, in whetting my skills to enable me to receive a message, under the worst possible conditions, and to achieve the highest possible rate of accuracy. To take a piece of traffic from a station that is in the noise level, or below, and to have as close to 100-percent accuracy, is the name of the game for me.

Then, along comes our friend with the brand new super-dupper, whiz bang, synthesized whats-it, and his Hakensak 5-PW amplifier, blasting the air waves with 3 or 4 kw, running up and down the band, with the key locked down; not just once or twice. No, he's got to run for it at least a half dozen times, before he qualifies. For what, I have yet to determine. And if, after all of this, you have anything left of your already diminishing hearing (having had the phones on, the bandwidth screwed down, and the volume up as high as you could stand it) your're *just lucky as all get out.*

I take exception to Mr. Morgan's, "wanting to hang them by their thumbs." While this just might keep them from reaching the key, and the VFO knob at the same time, it is quite doubtful that they would have learned anything from the experience. Given the fact that they have an extremely low I.Q. (they have already told this to the whole world) perhaps they need additional protection, namely from themselves. Perhaps an 8 or 9-foot square room, with lots of padding on the floor and walls, and a nice strong door, made from 3 inch thick planks, solidly set into the walls, would be appropriate.

I too have a chart, at the operating position, showing the dial setting for my antenna tuner for every 50 kHz, made some years ago during poor band conditions. With this chart, I am able to set-up a frequency, and not have my VSWR exceed 1.2:1. More than likely, it will be considerably below that value. Those times, when I do wind up with a 2:1 VSWR, it always turns out to be my fault for not reading the dial correctly. I have set the dial at 55 rather than 65, all of this without putting a signal on the air. When the time arrives that I have an amplifier in line, and up and running, it too will have a dial setting chart, compiled by operating the amplifier into a dummy load. If I can do this, so can you!!!

LeRoy E. Smith, WB0LTV, Hot
Springs, South Dakota 57747

A SIMPLE DIRECT CONVERSION TRANSCEIVER

By Rodney A. Kreuter, WA3ENK, 319 McBath Street, State College, Pennsylvania 16801

Here's another project using the NE602

I've always wanted to build a direct conversion receiver, but parts availability was a problem. I needed balanced mixers, matched schottky diodes, a good oscillator, and trifilar transformers. Then I received a sample of the Signetics NE602 and the incentive to build my receiver.

Of course, once you've built a direct conversion receiver, it's a simple matter to add a transmitter. And a keyer. And a good audio filter. And a digital readout. And a wind powered, nuclear backed-up power plant. And... And I wonder why I never get around to so many projects.

NE602

The NE602 is a relatively simple chip. I guess that's why I like it. Contained inside an eight-pin dip is a double-balanced mixer with about 15 db of gain, an oscillator, and a voltage regulator.

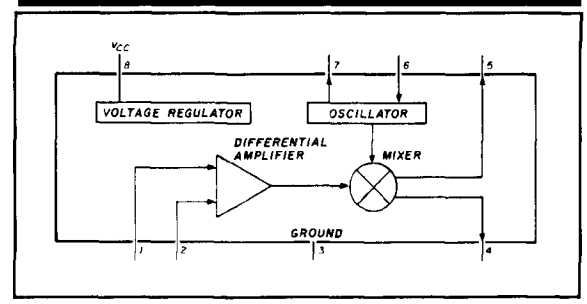
The chip was intended for the cellular radio market. The oscillator is good to 200 MHz and the mixer to 500 MHz. Not bad for less than 3 mA at 6 volts. (One of the Signetics application notes mentions that some people have used the mixer to 900 MHz, but they only guarantee it to 500 MHz.) It runs on 4.5 to 8 volts. But please, decouple the supply to the 602 with at least a resistor and a good bypass capacitor.

Inside the NE602

For a look inside the NE602, refer to fig. 1.

Input to the double-balanced mixer is differential (pins 1 and 2). If you don't have a differential signal, feed the signal into either input and bypass the other to ground

FIGURE 1



Basic functional block diagram of NE602.

with a capacitor. Under *no* circumstance should you provide a DC path from either input to ground. A DC path between inputs is okay. Input resistance is about 1.5k and input capacitance is about 3 pF.

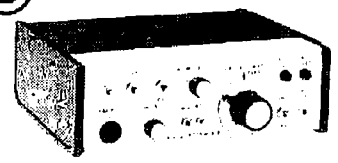
The oscillator is very simple. It's a transistor connected as an emitter follower with an internal resistor of 20k from the emitter to ground. If you want to try to push the upper frequency limit, connect an external resistor (22k minimum) from pin 7 (the emitter) to ground. This will increase the current and raise the Ft of the transistor. The base of the transistor is available at pin 6. It's already DC biased so don't provide a DC path from pin 6 to Vcc or ground. The output of the oscillator is internally connected to the other input of the double-balanced mixer.

The mixer output is also differential (pins 4 and 5) and has an output impedance of 1.5k. If you don't want a differential output, use one output and leave the other disconnected. Remember, this mixer has about 15 db of gain. One bad point — you can't push much of a signal through this mixer. It's third-order intercept is about -15 dBm. This is quite normal for a receiver, but it wouldn't make a great mixer for a transmitter power chain unless you mixed at a low level and provided a lot of gain after it.

The voltage regulator isn't mentioned much in the

AMATEUR TELEVISION

SMILE! YOU'RE ON TV



Only $299

Designed and built in the USA
Value + Quality from over 25years in ATV...W6ORG

With our all in one box TC70-1 70cm ATV Transceiver you can easily transmit and receive live action color and sound video just like broadcast TV. Use any home TV camera or VCR by plugging the composite video and audio into the front VHS 10 pin or rear phono jacks. Add 70cm antenna, coax, 13.8 Vdc and TV set and you are on the air...it's that easy!

TC70-1 has >1 watt p.e.p. with one xtal on 439.25, 434.0 or 426.25 MHz, runs on 12-14 Vdc @ .5A, and hot GaAsfet downconverter tunes whole 420-450 MHz band down to ch3. Shielded cabinet only 7x7x2.5". Transmitters sold only to licensed amateurs, for legal purposes, verified in the latest Callbook or with copy of license sent with order.

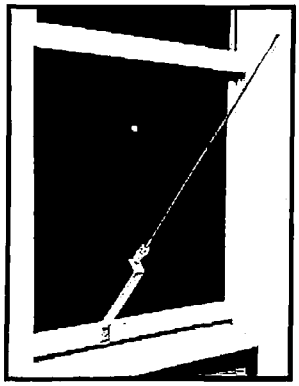
Call or write now for our complete ATV catalog including downconverters, transceivers, linear amps, and antennas for the 70, 33, & 23cm bands.

(818) 447-4565 *m-f 8am-5:30pm pst.* **Visa, MC, COD**

P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006
Tom (W6ORG)
Maryann (WB6YSS)

114

PORTABLE ANTENNA



MODEL AP-10

Designed for
APARTMENTS
MOTELS
VACATIONS

$64.95

Add $3.00
Shipping and Handling

Quick Simple Installation. Operates on 2, 6, 10, 15, 20, 30 and 40 meters. All coils supplied. Only 22-1/2 inches long. Weighs less than 2 lbs. Supplied with 10 ft. RG 58 coax and counter poise. Whip extends to 57 inches. Handles up to 300 watts.
VSWR—1.1:1 when tuned
Write for more details and other B&W products

ALL OUR PRODUCTS MADE IN USA

B&W BARKER & WILLIAMSON
Quality Communication Products Since 1932
At your Distributors. Write or Call.
10 Canal Street, Bristol PA 19007
(215) 788-5581

Signetics literature. My measurements and some data sheet "reading between the lines" lead me to believe it's about 4 volts. The *absolute* maximum input voltage to the regulator is 9 volts; maximum recommended input is 8 volts. It might be nice to use a 12-volt supply but you'll have to knock it down with a Zener or another regulator first.

Basic specifications for the NE602 are:

Power supply	4.5 to 8 volts	
Current consumption	2.4 mA	(typical)
Maximum mixer frequency	500 MHz	(typical)
Maximum oscillator frequency	200 MHz	(typical)
Noise figure	5 dB	(at 45 MHz)
Mixer gain	15 dB	(at 45 MHz)
Third-order intercept	– 17 dBm	(maximum)
Mixer input resistance	1.5k	(typical)
Mixer input capacitance	3pF	(typical)
Mixer output resistance	1.5k	(typical)
Mixer input capacitance	3 pF	(typical)
Mixer output resistance	1.5k	(typical)

Direct conversion receiver basics

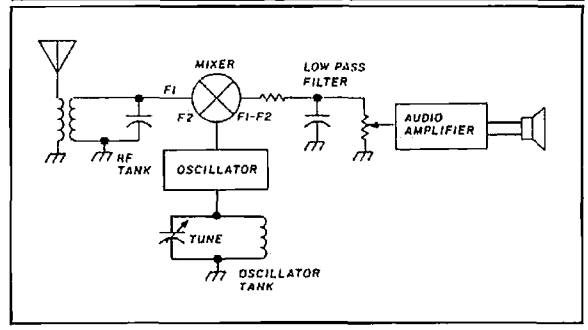
Direct conversion receivers have been sort of a fad for the past few years. If you need a refresher on the basics refer to **fig. 2.**

The RF signal is coupled into the mixer by the RF tank. The oscillator tank determines the oscillator frequency. The mixer combines these two frequencies and produces (at the output) the sum and difference of the two frequencies, plus the two original frequencies (at a minimum). If the oscillator frequency is very near the RF frequency, one of the output frequencies (the difference) will be in the audio range. The other frequency (the sum) will be at RF and will be attenuated by the low-pass filter. The remainder of the receiver is provided by lots of audio gain.

Most direct conversion receivers suffer from two problems:

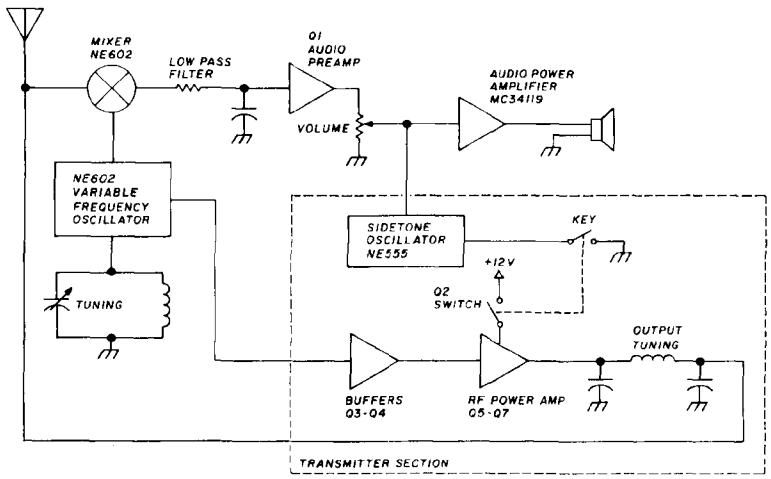
- Microphonics — Because most (if not all) of the signal gain is at an audio frequency, any slight vibration which might change

FIGURE 2



Block diagram of a typical direct-conversion receiver.

FIGURE 3



Block diagram of the direct-conversion transceiver.

the local oscillator comes through the speaker.

AC Hum — A 60-cycle hum created when operated from an AC supply.

These aren't real difficulties with the NE602. Using the NE602 won't cure the problems completely, but it will reduce them by two orders of magnitude. Most direct conversion receivers use diodes for a mixer. Instead of gain, these actually have about 6 dB of loss. The mixer used in the NE602 has about 15 dB of gain. Therefore the signal coming out of the mixer is about 20 dB higher in amplitude than one from a diode mixer. This means that a lot less audio gain is required after the mixer, and fewer audio problems occur.

Circuit description

Receiver

The receiver is very straightforward. (See **figs.** 3 and 4.) L2, C1 and C2 provide a broadband balanced input to the double-balanced mixer of the NE602. C13 through C18, and L3 are the tank and feedback circuits for the oscillator section of the chip. I realize you might question using six capacitors for an oscillator, so let me explain.

Capacitors C13 and C14 provide the feedback voltage divider for the oscillator. Capacitor C15 prevents the inductor from upsetting the DC bias of the oscillator. Capacitors C16, C17, and C18 are somewhat tricky.

These days it's very hard to get a good, affordable air-variable capacitor. I decided to use three capacitors instead. You'll find that by playing with these three capacitors, you can adjust the tuning range to almost anything you want. My prototype tunes from about 6.9 MHz to about 7.4 MHz, using the values shown. (Watch out for those band edges!) Decreasing C17 will make the tuning range smaller. If you have a 100-pF air variable, you may want to decrease C17 in order to make tuning a little easier. You can use a smaller "fine-tuning" capacitor in parallel with C18 with good results. A vernier dial might also come in handy here. Remember that this oscillator is also your transmitter VFO. Stability is everything!

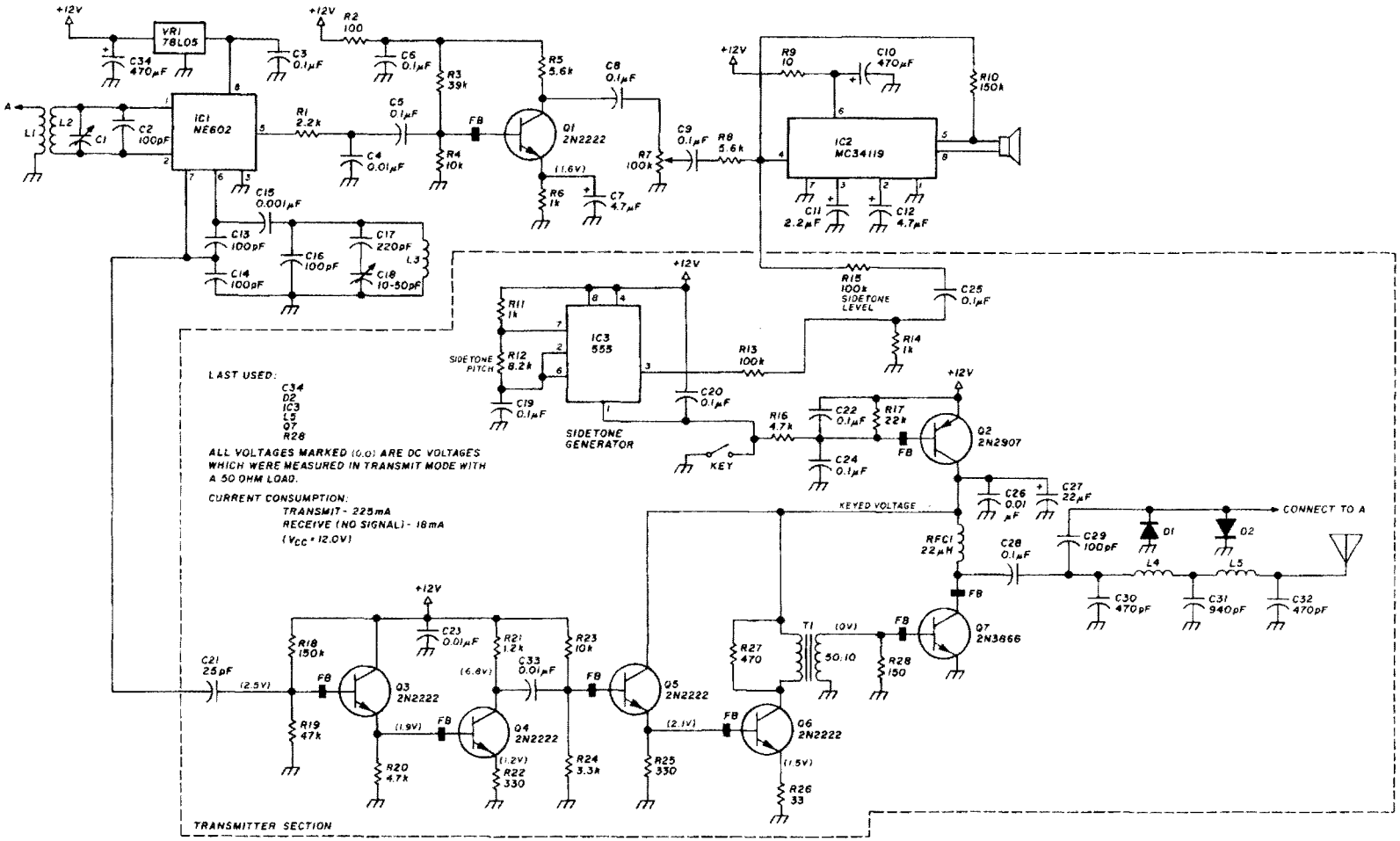
Since I've already mentioned that the NE602 contains a voltage regulator, you're probably wondering why I used a 78L05 to regulate the voltage to the NE602. First, it never hurts to have a good stiff power supply for an oscillator. Second, it's used to isolate the NE602 from the power supply. My first prototype (there were four) simply used a resistor and a capacitor for power supply decoupling. I had a lot of audio gain and the feedback was terrible. The 78L05 isolates the NE602 very well.

R1 and C4 are used as a low-pass filter for audio (about 4.3 kHz including the 1.5k output impedance of the NE602). R2 and C6 are used to prevent the audio output from reaching Q1 through the power supply.

Q1 is a simple audio-gain stage. I originally used a dual op amp for this function, but found that I didn't need nearly that much gain. The gain of Q1 in this configuration is about 150-200. Resistor R3, one of the bias resistors, can be varied to adjust the gain if you feel it's necessary. Lowering R3 will increase the gain. Just be sure not to saturate Q1.

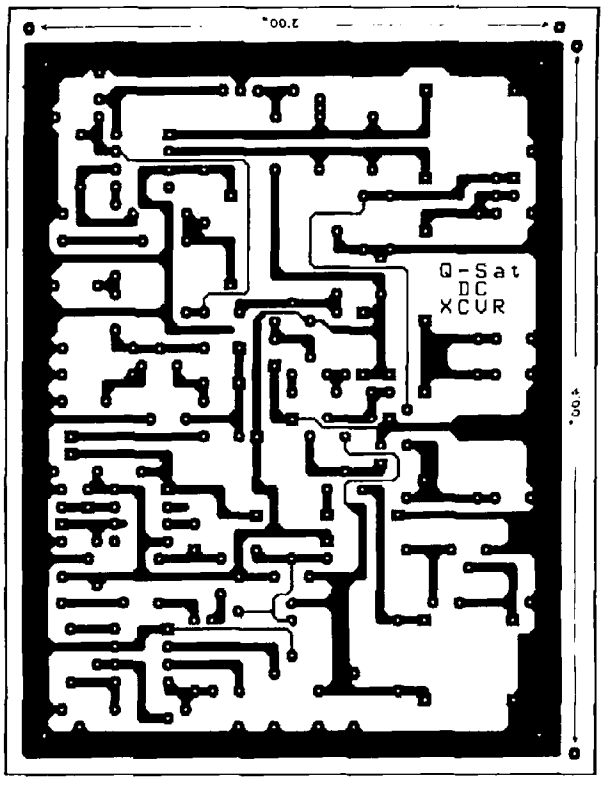
IC2 is an audio power amplifier that seems to be replacing the LM386. The output is differential and doesn't require a large capacitor to couple it to the speaker. Just keep the speaker leads short (a few inches) and twist them tightly. R9 and C10 decouple the amplifier from the power supply and are necessary to prevent

FIGURE 4



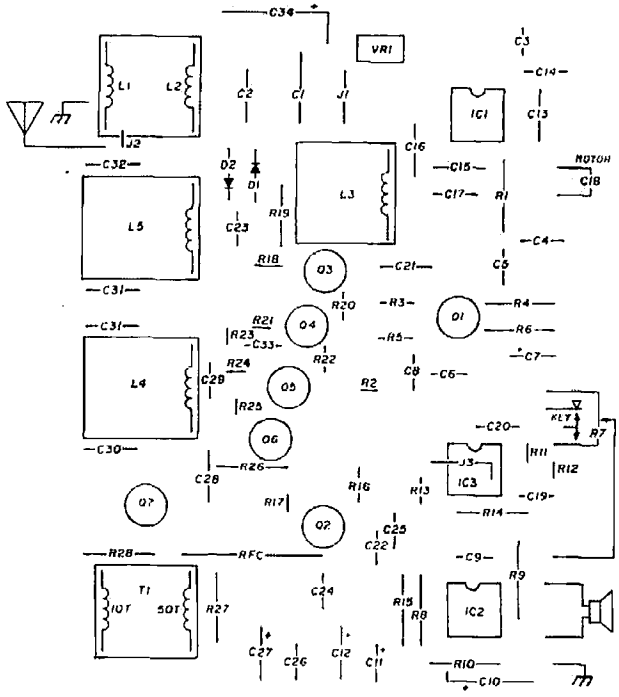
Schematic diagram of a simple direct-conversion CW transceiver.

FIGURE 5



Printed circuit board layout.

FIGURE 6



Parts placement.

audio feedback. After all, 80 dB of gain at one frequency is a little hard to control.

Transmitter

For the transmitter description refer to **figs. 3** and **4**. The oscillator output is coupled to an emitter follower (Q3) by means of C21. This provides buffering of the oscillator so that the transmitter doesn't "pull" it.

Transistor Q4 provides the first voltage gain for the RF signal. Its purpose is to supply enough drive for the next emitter follower, Q5. Most simple crystal-controlled transmitters probably wouldn't need this additional gain because their oscillators provide enough output power to drive a 1-watt output stage directly.

Q5 provides a low impedance drive for the input of the first class "C" amplifier, Q6. Transformer T1 is used mainly to furnish a high impedance load for Q6 and a low impedance drive for Q7. I tried to do away with T1 by using another emitter follower in its place. It worked, but not very well. The two transistors consumed too much power. This was unacceptable because this transceiver was designed to be battery operated.

Q7 is used as the RF power amplifier. A 2N3866 or a 2N3553 seemed to work well. Notice the double pi output filter. I used a double pi filter instead of the more common single pi to ensure a clean output. I would have liked to use variable capacitors for C30, C31, and C32, but I wanted to keep the circuit as simple as possible and I knew that good variables for these capacitors can be hard to obtain. It may be difficult to find a 940-pF capacitor for C31. The pc board is laid out to accept two capacitors in this position. Use any parallel combination to get 940 pF.

IC3 is a 555 used as a side-tone monitor. You can adjust the pitch of the side tone by changing R12. A lower value increases the pitch. Adjust side-tone volume by changing R15.

Capacitor C29 couples energy from the antenna into L1 for the receiver. Diodes D1 and D2 protect the front end of the receiver during transmit. If you're going to build just the receiver, place a jumper (J2) on the board to couple the antenna into L1. You won't use the double pi network unless you're also building the transmitter section. Omit J2 if you're buliding the complete transceiver.

Transistor Q2 keys the power to transistors Q5, Q6,

PARTS LIST

Receiver	
* C1	50 or 60 pF trimmer
C2,C14,C16,C13	100 pF
C3,C5,C6,C8,C9	0.1 μF
C4	0.01 μF
C7,C12	4.7 μF 16 volt
C10,C34	470 μF 16 volt
C11	2.2 μF 16 volt
C15	0.001 μF
C17	100 to 220 pF (see text)
* C18	10-50 pF variable (see text)
* IC1	Signetics NE602 (Oscillator/mixer)
* IC2	Motorola MC34119 (Audio power amp)
L1	30 turns no. 26 on T-37-2 core
L2	5 turns no. 26 over L1
L3	25 turns no. 26 on T-37-2 core
* Q1	2N2222
R1	2.2k
R2	100 ohms
R3	39k
R4	10k
R5,R8	5.6k
R6	1k
R7	100k audio taper
R9	10 ohms
R10	150k
* VR1	78L05 (5-volt voltage regulator)
* Printed Circuit Board	
* (2) T37-2 Toroid cores	
* (1) Ferrite bead	
Transmitter	
C19,C20,C22	
C24,C25	0.1 μF
C28	0.1 μF 50-volt minimum
C21	25 pF
C23,C26,C33	0.01 μF
C27	22 μF 16 volts
C29	100 pF
C30,C32	470 pF
C31	940 pF (or two 470 pF in parallel)
* D1,D2	1N914 or 1N4148
* IC3	NE555 (Side-tone oscillator)
L4	15 turns no. 26 on T-37-2 core
L5	15 turns no. 26 on T-37-2 core
* Q2	2N2907
* Q3,Q4,Q5,Q6	2N2222
* Q7	2N3866 or 2N3553
R11,R14	1k
R12	8.2k
R13,R15	100k
R16	4.7k
R17	22k
R18	150k
R19	47k
R20	4.7k
R21	1.2k
R22,R25	330 ohms
R23	10k
R24	3.3k
R26	33 ohms
R27	470 ohms
R28	150 ohms
* RFC1	22 μH
T1	Primary 50 turns no. 30 enamel Secondary 10 turns no. 26 on T-37-2 core
* (3) T-37-2 Toroid cores	
* (6) Ferrite beads	

The following may be ordered from:

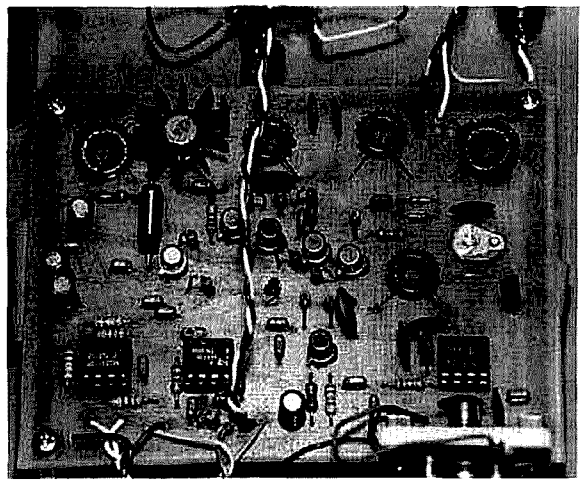
Q-Sat
P.O. Box 110
Boalsburg, Pennsylvania 16827
PC Board—PCB—DXCVR $9 plus $1 postage and handling

*Hard-to-find receiver parts (marked with * above)*
DXCVR—REC $19 plus $2 postage and handling (includes PC Board)

*Hard-to-find parts for transceiver (marked with * above)*
DXCVR—T/R $26 plus $2 postage and handling (includes PC Board)
Pennsylvania residents please add 6 percent sales tax

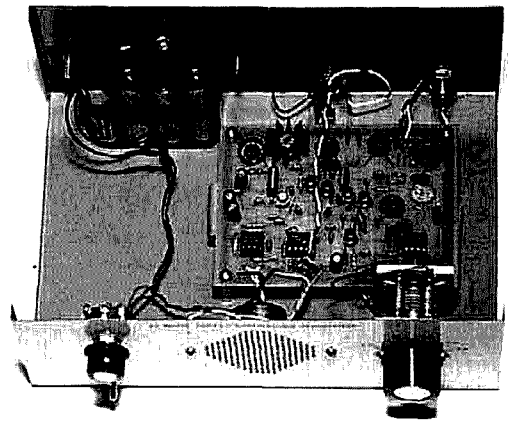
and Q7. Resistor R16 and capacitor C24 provide output wave shaping. You may increase capacitor C24 to provide a "softer" output waveform.

PHOTO A



Top view of pc board. The two 470-μF caps are mounted underneath.

PHOTO B



inside View. There's still plenty of room for an audio filter.

Construction

I recommend using the pc layout in **figs. 5** and **6**. There's a lot of gain in this receiver and the transmitter has enough of its own.

Fifteen turns of wire on a toroid core sounds simple enough, but don't believe you can't tweak a toroid coil. Spreading out or compressing the turns can change the inductance about 10 percent. If you have a grid-dip meter, you must couple into a toroid with a single-turn link. Don't expect to make any reasonable measurements just by placing the dip meter near a toroid. Remember that turns on a toroid are counted by the number of turns on the inside of the core, not the outside.

Mount the variable capacitor (C18) firmly. Hand

COMPUTERIZE YOUR SHACK

YAESU 747, 757GX, 757GXII, 757, 9600.
KENWOOD TS 140, 440, 940, 680, R5000.
ICOM R71A, R7000, 735, 751A, 761, 781, AND ALL VHF, UHF, CI-V.
DRIVERS FOR RADIOS ARE MODULAR.
JRC NRD 525.

COMPLETE PROGRAM ENVIRONMENT.
MENU DRIVEN AND DESIGNED FOR EASE OF USE.
SCAN FUNCTION ADDED TO RADIOS THAT DO NOT SUPPORT IT.
ERGONOMETRICALLY DESIGNED FOR EASE OF OPERATION.
MOST FUNCTIONS REQUIRE SINGLE KEYSTROKES.
PROGRAM COLOR CODED FOR EASE OF USE, ALTHOUGH WILL STILL RUN IN A MONOCHROME SYSTEM.

MENUS FOR THE FOLLOWING:
AMATEUR HF—AMATEUR VHF— AMATEUR UHF
AM BROADCAST—FM BROADCAST—TELEVISION BROADCAST
SHORT WAVE BROADCAST
AVIATION HF(SSB)—AVIATION VHF—AVIATION UHF
HIGH SEAS MARINE—VHF MARINE
MISCELLANEOUS HF, VHF, UHF
MOST POPULAR FREQUENCIES ALREADY STORED
ADDITIONAL LIBRARIES AVAILABLE
COMPLETE LOGGING FACILITY
ALL FREQUENCY FILES MAY BE ADDED TO, EDITED OR DELETED

AVAILABLE FOR IBM PC, XT, AT, 80386 256K RAM
1 SERIAL PORT AND 1 FLOPPY MINIMUM

PROGRAM WITH INITIAL LIBRARIES	**99.95**
RS-232 TO TTL INTERFACE ONLY (NEEDED IF DON'T HAVE MANUFACTURERS INTERFACE)	
EXTERNAL INTERFACE ALLOWS 4 RADIOS	**99.95**
INTERNAL PC INTERFACE W/1 SERIAL & 1 RADIO PORT	**129.95**
SPECTRUM ANALYZER MODULE	(CALL FOR PRICE)
COMPLETE SYSTEMS INCL. RADIO, INTERFACE, COMPUTER, AVAILABLE	(CALL FOR PRICE)

DATACOM, INT.
8081 W. 21ST LANE
HIALEAH, FL 33016
AREA CODE (305) 822-6028

117

EXCITING OPPORTUNITIES AT cushcraft CORPORATION

IN-HOUSE SALES

Cushcraft, Amateur Radio's innovative antenna manufacturer, is looking for a qualified person for their in-house sales office. Working knowledge of communications and Amateur Radio are required. Good verbal skills and a proven sales track record with two to four years experience a must.

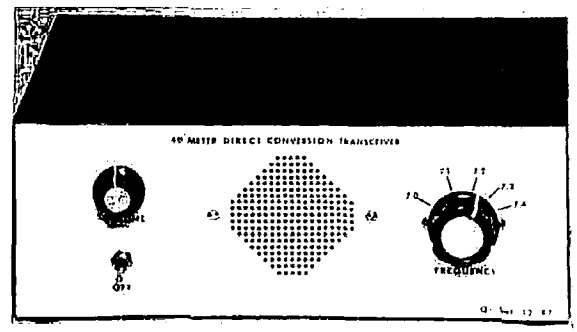
LAB TECHNICIANS

Cushcraft is also expanding its Product Development Lab. Experienced technicians are needed. Applicants should have a working knowledge of RF. A degree is not required if the applicant has equivalent experience. Electro Mechanical experience would be helpful.

Send your resume to:

cushcraft CORPORATION
48 Perimeter Road
Manchester, NH 03108

PHOTO C



The completed unit. Antenna and key connectors are on the rear panel.

capacitance can be a problem before it's put in a metal case. Also make sure that the rotor is the terminal used for ground. See **photos A** and **B** for internal details. **Photo C** shows the completed unit.

Don't expect reasonable performance without a reasonable antenna. Although I've been known to throw a piece of wire on the family room floor and attempt to listen to the receiver, it doesn't work very well. A good ground helps.

I mounted some resistors in a vertical position on the pc board to save room. In these cases, one of the pads will be square. Mount the body side of the resistor to the square pad.

Modifications

You can make the basic transceiver work on almost any band; however, operation above 20 meters might be difficult due to the stability of the oscillator.

An audio filter would make a nice addition. It should be easy to add one in series with the volume control, because wires are brought out from the board at this point.

Stability

Before I address the topic of stability, I'd like to recommend that you don't attempt to build any transmitter if you don't have a scope (or better yet, a spectrum analyzer) or access to one. Tracking down stability problems without one is simply too frustrating. A local ham club certainly should be able to help. I know that many people will think that a properly designed transmitter should be no problem, and if we all used 50-ohm load resistors instead of antennas, that would be true. The difficulty is that it's impossible to design an efficient transmitter that will work with any given load.

My basic philosophy about stability is that I would rather put a clean 1/2-watt signal into an antenna than a dirty 10-watt one. Even if the "spurs" are 30 dB down,

I'm not satisfied. Spurs should be down a minimum of 50 dB.

I did have some stability problems. When I fired up the transmitter, it was into a very good 50-ohm load. The output was about 3/4 watt (17 volts p-p), and it was very clean across the entire tuning range. Then came the antenna test — or rather the antenna disaster. I'll be the first to admit that this antenna leaves a lot to be desired. I've moved recently, and haven't had time to do a proper job of planting the antenna farm. The antenna in question is a simple half-wave dipole about 10 feet off the ground at one end and 20 feet at the other. It resonates somewhere. Anyway, the output was fine at some frequencies. At others there was some 7 MHz energy left, but not much.

The solution wasn't simple. First of all, it seemed that transformer T1 was ringing like mad. Lowering the value of resistor R28 and adding R27 calmed it down. The input of the output transistor (2N3866) I used looks very capacitive at 7 MHz. R28 prevents this capacitance from resonating with the secondary of T1. This cleaned up 90 percent of the problem. Next I "empirically derived" (played with) the turns ratio of T1. This helped a little. I reduced the "Q" of T1 using R27; this helped a little more.

I also found out that I didn't have enough drive, so I went back to the proverbial drawing board and added stage Q4. One tip — if you're not getting at least 600 to 800 mV p-p at the emitter of Q3, play with the ratios of C13 and C14. I tried making C13 as small as possible, but I didn't get enough drive for Q3 until I increased C13 to 100 pF.

Stubborn cases may require a resistor in parallel with RFC1; a thousand ohms should do it. And don't forget the ferrite beads on the collector and base of Q7 and the other transistors.

TABLE 1

The following voltages (p-p and DC) are given as an aid in troubleshooting any problems you might have. All of the signals are 7-MHz sine waves. Data was taken with a 12-volt power supply and the unit was in the transmit mode with a 50-ohm load.

	AC (p-p)	DC
Emitter of Q3	700 mV	1.9 volts
Collector of Q4	1.1 volts	6.8 volts
Emitter of Q5	1.6 volts	2.1 volts
Collector of Q6	17 volts	12 volts
Base of Q7	2.9 volts	0 volts
Collector of Q7	18 volts	12 volts
Antenna Output (50-ohm load)	18 volts	0 volts
NE602 (pin 7)	700 mV	4.5 volts

Table 1 gives typical voltages for troubleshooting purposes.

Bibliography

1. *Signetics Linear Data Manual Volume 1 – Communications*, Signetics Corp.
2. Robert J. Zavrel, Jr., W7SX, "Designing with the NE/SE602," Signetics Application Note AN198, Signetics Corp.
3. Robert J. Zavrel, Jr., W7SX, "New Low Power Single Sideband Circuits," Signetics Application Note AN1981, Signetics Corp.
4. Donald Anderson, "Applying the Oscillator of the NE602 in Low Power Mixer Applications," Signetics Application Note AN1982, Signetics Corp.
5. RCA Solid State Power Circuits, Technical Series SP-52.
6. Wes Hayward, W7ZOI and Doug DeMaw, W1FB, *Solid State Design for the Radio Amateur*, American Radio Relay League.
7. Doug DeMaw, W1FB, *QRP Notebook*, American Radio Relay League.
8. Chris Bowick, *RF Circuit Design*, Sams Publishing.
9. Motorola RF Device Data – DL110 Rev. 1, Motorola, Inc.

Article A

HAM RADIO

THE MULTIPLE RECEIVER SOLUTION



4 Channel Signal-to-Noise Voter

- Expandable to 32 Channel by Just Adding Cards
- Continuous Voting
- LED Indicators of COR and Voted Signals
- Built in Calibrator
- Remote Voted Indicators Panned Out
- 4" x 6 Double Sided Gold Plated 44 Pin Card
- Remote Disable Inputs
- MORE

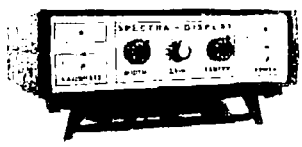
Built, tested and calibrated with manual

$350.00

Telephone interface now available
For more information call or write

DOUG HALL ELECTRONICS
Voter Department
815 E. Hudson Street
Columbus, Ohio 43211
(614) 261-8871

118

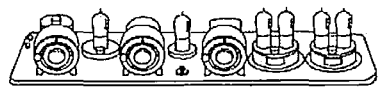


R-7000 Widespan Panadaptor

Panadaptor especially designed for the R-7000 receiver. For use with a standard scope. Variable span width from 1 to 10 Mhz. Uncover unknown elusive signals. Complete with all cables, & 90 day warranty. $349.95 Shipped. Pa. res. add 6%.

GTI Electronics
RD 1 BOX 272
Lehighton, Pa. 18235
717-386-4032

119



IF YOU BUY, SELL OR COLLECT OLD RADIOS, YOU NEED...

ANTIQUE RADIO CLASSIFIED

Antique Radio's Largest-Circulation Monthly Magazine



FREE SAMPLE COPY!

Classifieds - Ads for Parts & Services
Articles - Auction Prices-Flea Market Info.
Also: Early TV, Ham Equip., Books, Telegraph, Art Deco, 40's & 50's Radios & more...
Free 20-word ad each month. Don't miss out!

6-Month Trial - $11.
1-Year: $19 ($28 by 1st Class)
Foreign by air – Canada: $30; Mexico: $28; Other: $55.

A.R.C., P.O. Box 2-A4, Carlisle, MA 01741

120

THE WEEKENDER



Build this simple L-C checker

This simple capacitance-inductance checker measures capacitance to approximately 1000 pF and inductance to 50 μH. I first saw it described in *QST* some 36 years ago.[1] That version used a filament-type tube (3A5) in a self-rectifying oscillator powered from 115 volts AC. I built one in a cigar box lined with metal foil. It's seen constant use in my shack with the original tube!

The initial L-C checker measured capacitance only. I modified it to add inductance measuring capability when I transistorized the unit.

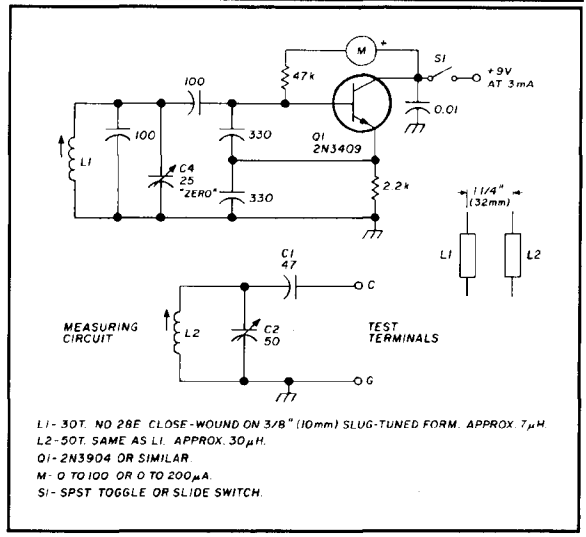
The capacitance circuit measures to 5000 pF or more; however, accuracy and resolution are reduced above 1000 pF because of circuit limitations. But, when you pick a mica capacitor marked with two red dots from your junkbox, this unit will quickly tell you if it's 2.2, 22, or 220 pF. The device has the advantage of applying no voltage or current (other than a few millivolts of RF) to the capacitance or inductance under test.

How it works

The circuit is based on the "grid-dip" or absorption effect, which occurs when a parallel resonant circuit is coupled to an oscillator of the same frequency. If you look at **fig. 1**, you'll see that Q1 operates in a conventional Colpitts oscillator circuit at a fixed frequency of approximately 4 MHz. The exact frequency isn't critical. A meter connected in series with the transistor's base-bias resistor serves as the "dip" or absorption indicator.

By Jack Najork, W5FG, 723 Flamingo Way, Duncanville, Texas 75116

FIGURE 1



L1 - 30T. NO 28E CLOSE-WOUND ON 3/8" (10mm) SLUG-TUNED FORM. APPROX. 7μH.
L2 - 50T. SAME AS L1. APPROX. 30μH.
Q1 - 2N3904 OR SIMILAR.
M - 0 TO 100 OR 0 TO 200μA.
S1 - SPST TOGGLE OR SLIDE SWITCH.

Schematic diagram of L-C checker with measuring circuit for measurement of capacitance only. L1 and L2 should be spaced as shown for optimum electrical coupling.

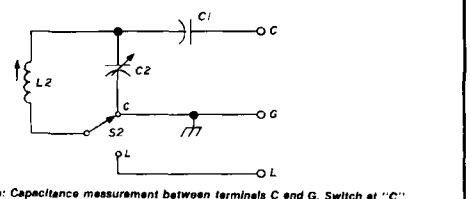
The variable measuring circuit consists of C1, C2, and L2 and is connected to panel terminals as shown. L2 is loosely coupled to L1 in the oscillator circuit. This measuring circuit is tuned to the oscillator frequency with variable capacitor C2 set at full or (maximum) capacitance. When power is applied to the oscillator the meter shows a dip caused by power absorption by the measuring circuit.

Connecting an unknown capacitor across the test terminals lowers the resonant frequency of the measuring circuit. To restore resonance, tune capacitor C2 lower in capacitance. The meter will dip again when you reach this point. Determine the capacitance across the test terminals by calibrating the dial settings of C2. More on this later.

Capacitor C4, a small variable trimmer in the oscillator circuit, compensates for drift or other variations and is normally set at half capacitance. It's a panel control, labeled "ZERO", and is used to set the oscillator exactly at the dip point when C2 is set at maximum capacitance. This corresponds to zero on the calibration scale.

You can also use C4 to compensate for the capacitance inherent in long leads running from the test terminals to the unknown capacitor. The leads are connected to the test terminals and dressed close to the capacitance to be measured, but not connected to it. Adjust C4 for a dip with C2 at zero. Then connect the leads and make your measurement.

FIGURE 2



Addition of S2 to the measuring circuit enables measurement of both capacitance and inductance. Note: For capacitance measurement between terminals C and G, switch at "C". For inductance measurement between terminals L and G, switch at "L".

Measuring inductance

After I got the transistorized version working, it occurred to me that I should be able to use the circuit to measure inductance as well. **Figure 2** shows how. The oscillator circuit remains unchanged. Add an SPDT switch (S2) to the measuring circuit. With S2 in the "C", or capacitance measuring position, the circuit is as before. In the "L", or inductance measuring position, the switch disconnects the bottom of L2 from ground and connects it to a third panel terminal marked "L".

Connecting an unknown inductance across the "L" and "G" terminals again lowers the resonant frequency of the measuring circuit because the unknown inductance is now in series with L2. You must tune C2 lower in capacitance again to restore resonance. As with capacitance measurements, the best resolution occurs at the lower inductance values.

To measure inductance, set S2 to "C" and adjust the oscillator (ZERO) control for a dip with C2 at zero. Set the switch to "L" and connect the unknown inductance across the "L" and "G" terminals.

Construction notes

You'll need solid construction for consistent calibration accuracy. Use the VFO construction techniques from any handbook. Choose a good-sized, sturdy metal cabinet so that you can use a large dial or pointer for the measuring capacitor, C2. I glued a 2-inch pointer to my dial and spread the calibration marks across the largest dimension of the cigar box.

The spacing (electrical coupling) between L1 and L2 isn't critical, though it can be adjusted if necessary. Wider spacing produces a shallower dip, but improves the measuring resolution. Conversely, closer spacing (coupling) produces a more pronounced dip, which lowers resolution.

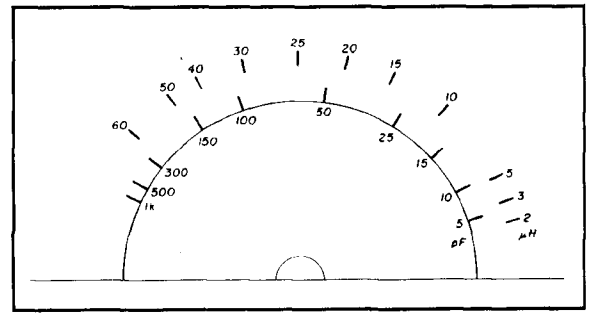
Make the wiring from the bottom of L2 to switch S2, and from S2 to the panel terminal "L", short and low inductance. Use heavy wire or copper ribbon, because these connections form a portion of the unknown inductance placed across terminals "L" and "G". Too much inductance in these connections produces erroneous inductance readings when measuring very small inductances.

Calibration

Calibrate the capacitance range by placing known values of capacitance across the "C" and "G" terminals and marking these values on the C2 dial or pointer. Most of us have enough well-marked mica and ceramic capacitors in our junkbox to make this easy. Don't forget, you can also use these capacitors in parallel or series, as needed.

Inductance scale calibration is a bit tougher. You might want to beg, borrow, or otherwise obtain a collection of small, molded RF chokes. I had a half dozen 10-μH chokes and used them in series and parallel to calibrate. This method may not result in laboratory-type accuracy, but it'll bring you right into the ballpark. **Figure 3** shows my unit's calibration.

FIGURE 3



Typical range scale calibration made with C2 and 50 pF, Hammarlund HF 50 with semi-circular plates. Capacitors with a different plate shape will yield a different calibration.

Using other parts

You engineering types will by now have observed that juggling the values of C1 and C2 alters the range and linearity of the measuring range. For example, increasing C1 expands the calibration at the low picofarad end but limits the upper capacitance measurement. If L2 is an adjustable coil, as shown, select C1 and C2 for the desired results, retuning L2 as needed to restore resonance.

If your junkbox dictates, use a larger value capacitor for C2. This requires increasing the value of C1. One possible combination is 150 pF for C2 and 130 pF for C1, with L2 reduced to approximately 10 μH. To limit the inductance measuring range with this com-

bination it's necessary to add a small fixed capacitor in parallel with C2. Try 10 to 15 pF.

If the required microammeter isn't available, take heart. Since the unit draws around 3 mA at 9 volts, you can use a zero to 5 mA meter in series with the + lead to the power source. Resonance will now be indicated by a *rise* in the meter reading instead of a dip. The variation between dip and non-dip won't be as pronounced as with a base current meter, but it will be usable.

If 3/8-inch diameter coils aren't available you can use 1/4-inch forms. Scrounge them from the i-f section of a defunct TV set. You'll need more turns, and the "Q" will be a bit lower, but they'll work. Conversely, for those who want improved resolution, substituting larger diameter coils wound with heavier wire will increase "Q". This enables looser coupling which in turn produces a sharper dip.

References

1. *QST*, March 1952.

Article B

HAM RADIO

QuicKit G5RV, Loop, & Dipole Kits

Fast & Easy to Build
- Everything included
- Failsafe visual instructions
- No measuring / cutting
- Finish antenna in minutes

Quality Components
- Presoldered Amphenol PL-259
- Kinkproof Superflex wire
- Fully insulated, wax sealed, no corrode, low noise design

Fastest Antennas in the West

AntennasWest

(801) 373-8425

- Full Size G5RV dipole coverage 80-10 $34.95
- Half Size G5RV dipole coverage 40-10 $24.95
- Quarter Size G5RV dipole coverage 20-10 $19.95
- Marconi Adapter Kit $ 4.95
- Antenna Launcher Kit $14.95
- 200' Dacron 2500 line $11.95
- Loops, dipoles, feedlines, etc.

Add $5 Shipping & Handling
Catalog $1 by 1st class mail

Box 50062-H, Provo, UT 84605

122

Look at our MOBILE MARK "ON WINDOW" Line

VHF (140-175)
- No Hole
- Easy to Mount
- Rugged
- Superior Performance
- Radiator Snaps On and Off
- Competitively Priced

UHF (420-520)
- 3 db gain
- No Hole
- Easy to Mount
- Rugged
- Superior Performance
- Radiator Snaps On and Off
- Competitively Priced



MODEL OW 3-150
140-174 MHz
MODEL OW 3-220
210-250 MHz
- 3 db gain
- No Hole
- Easy to Mount
- Rugged
- Superior Performance
- Swivel Vertical Adjustment
- Radiator Removal Without Loss of Vertical Adjustment
- Competitively Priced



MOBILE MARK, INC
COMMUNICATIONS ANTENNAS
3900-B River Road
Schiller Park, IL 60176
312-671-6690



brings imagination and innovation to antennas ..... and has been since 1948 !!

121

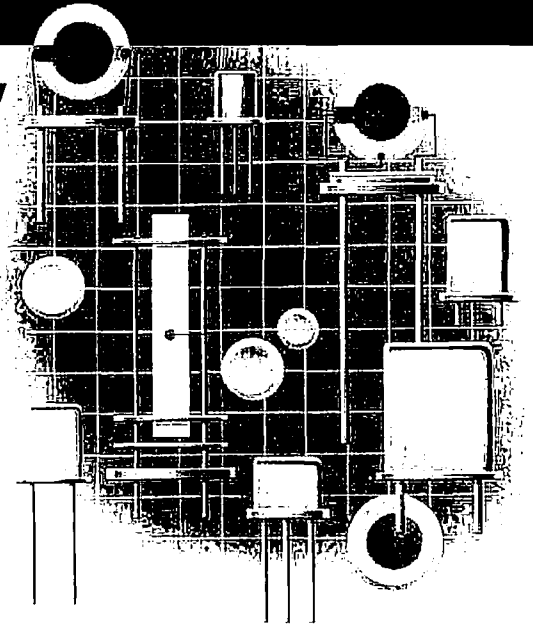
CUSTOM CRYSTALS

Crystals for many applications

For over 37 years, ICM has manufactured the finest in quartz crystals for every conceivable purpose.

A wide selection of holders are available to fit most any requirement. Our computer database contains crystal parameters for thousands of equipment types.

Need crystals for communications, telemetry, industrial, or scientific applications? Let ICM's sales department assist you to determine which type of crystal is best for you.



Can we solve your crystal problem?

For special purpose crystals, special holders, special sizes, call our crystal sales department. We will be pleased to provide recommended data.

ICM

International Crystal Manufacturing Co., Inc.

P.O. Box 26330, 701 W. Sheridan
Oklahoma City, OK 73126-0330
Phone (405) 236-3741
Telex 747-147
Facsimile (405) 235-1904



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

New Zealand, Maui, and the Solar Cycle

My visit to New Zealand was wonderful! I attended and spoke at the NZART (New Zealand Association of Radio Transmitters) Convention at Whakatane. Then I took a leisurely trip around the North Island, visiting such notables as ZL1AAS, ZL1BRQ, ZL1SZ, ZL2JQ, and ZL2AM. The combination of hospitality and beautiful countryside was overwhelming. I had the privilege of operating with my reciprocal call, ZLØSAI. It's interesting to hear what a pile-up on 20-meter SSB sounds like from the DX end. After a quick call, the S meter on the KWM-2 went over against the pin and stayed there! Beaming north-east across the United States and into Europe, it was interesting to note that the European signals were almost as loud as the W6s. Ear-splitting signals were also noted from "locals" like UJ8, UD6, 9N1, and 4S7.

I saw more homemade tilt-over towers in New Zealand than I'd ever seen in California. The crank-up tower doesn't seem to be very popular; many DXers favor the tilt-over type. Most of them use a 20-foot high base structure and a tilt-over top section, ranging from 18 to 25 feet long. Some monster tilt-over towers, like the one at ZL1AAS, are nearly 80 feet high. All of them are counterbalanced so that little effort is required to raise or lower the top section.

Do any of you have a homemade tilt-over tower? If so, I'd like to hear about it; send pictures and drawings, if possible.

The mild climate, beautiful scenery, and friendly people make New Zealand a perfect place to visit. On your way there, stop in Tahiti or Fiji for a touch of the exotic. Truly, New Zealand is a little corner of paradise! Thanks to all who made the visit so pleasant for me.

Next stop Maui

After New Zealand, I stopped at Maui, Hawaii and visited Steve, KH6SB, who runs the island's NOAA Ionospheric Observatory. Here, talk turned to DX and the sunspot cycle. Steve showed me readings and graphs taken from recent ionospheric sounding measurements. I remembered various statements in DX newsletters predicting that the peak of cycle 22 might be greater than any previously experienced, and that it could be reached as soon as December 1988 — right about now. I queried Steve about this. His data indicated that the International Smoothed Sunspot Number (taken as gospel by many Amateurs) showed a cycle quite different from the Geomagnetic A Index, the Ottawa Radio Flux (10 cm), or the ionospheric measurements of the maximum frequency of F_2 reflection measured at Maui. (See **fig. 1**.) According to Steve, a lot depends upon which cycle you're talking about.

The Maui vertical sounding of the F2 layer showed a minimum value centered about April/May, 1986. The smoothed sunspot numbers indicated a minimum falling during September 1986 for old cycle 21. The Geomagnetic Index indicated a minimum near January 1987, and the Ottawa Radio Flux had a broad minimum covering April 1985 to October 1986.

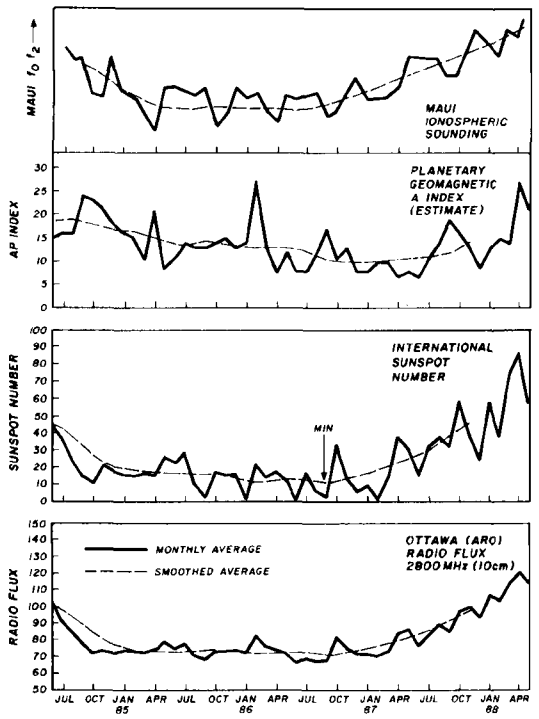
So where do we go from here? When will the present ionospheric cycle peak out? *QST*'s "How's DX" column indicates a peak at the end of 1988. Steve showed me a graph of the median values of the maximum reflecting frequency of the F_2 layer, as measured at his station (**fig. 2**). He pointed out that the slope of the present increase is just about the same as that of the last cycle. Steve thinks that the peak of the present cycle may arrive around the fall of 1990, and that it will be very similar to the last.

Time will tell. Meanwhile, enjoy 10-meter DX and don't overlook the amazing things that are happening on the 6 and 2-meter bands.

RFI from cordless phones?

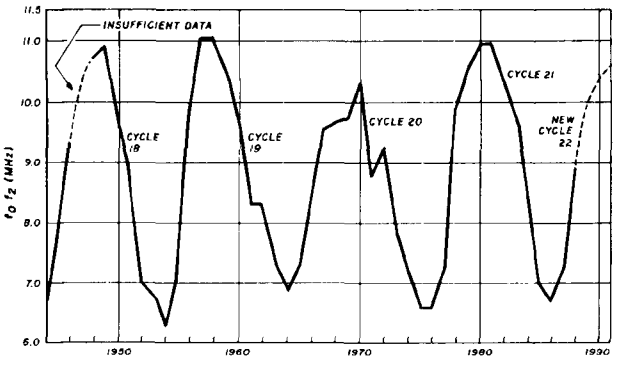
The June issue of *Modern Electronics* has an article by C. Hall describing TVI from a neighbor's cordless telephone. The phone transmitted

FIGURE 1



Comparison of cycles of ionospheric sounder (Maui) with A-index, sunspot number, and radio flux over the period July 1985 to April 1988 shows that the individual cycles have quite different minimums.

FIGURE 2



Median values for the month of May for the ionospheric readings at Maui, Hawaii in terms of maximum vertical reflected frequency (F_0F_2) of the F_2 layer. Note that the rising slope of cycle 21 and cycle 22 is approximately the same. The best estimate is that the present cycle will peak out in the fall of 1990.

FM signals on a frequency in the range of 46.61 to 46.97 MHz (base) and 49.67 to 49.99 (handset). These frequencies were perilously close to various TV picture i-f amplifier circuits that operate at 45.75 MHz.

A high-pass filter on the TV set did no good; the cutoff frequency of the filter was higher than the telephone band. The solution was to cut a linear trap made from 300-ohm ribbon line and place it across the receiver antenna terminals in parallel with the existing transmission line (**fig. 3**). The trap was cut to a length of 50.25 inches to tune it to the center of the cordless phone band. (This length takes into account the velocity of the propagation factor of the line.) Hall said this eliminated the herringbone lines on the TV screen caused by the cordless telephone.

A compact wire antenna for 7 and 21 MHz

It's hard to be loud on a city lot, and erecting a 66-foot long, 40-meter dipole can be a challenge in some locations. **Figure 4** shows a compact, space-saving antenna designed by V.C. Lear, G3TKN. It's been discussed in RSGB's *Radio Communication* and other European magazines. As far as I know, it hasn't been publicized on this side of the pond. In brief, it's a 40-meter dipole shortened to about 54 feet by folding the center portion of the radiator up into a two-wire transmission line. The lengths of the top section are chosen to provide two 5/8-wavelength sections in phase on 21 MHz.

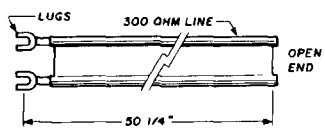
The antenna supplies the usual figure eight pattern on 40 meters, and a somewhat narrower figure eight on 21 MHz. Best of all, there's about a 3-dB gain over an equivalent dipole on 21 MHz.

The folded, two-wire stub has a spacing of 6 inches and is made of no. 16 wire. The end of the stub is matched to a coax line by way of a 1:1 balun, like the Bencher ZA-1A.

The two-wire line is spaced with 3/8-inch diameter spreaders cut from Lucite® , Plexiglas®, or other insulating rod material. Holes are drilled at the outer ends to pass the wires, which are held in position by twisting short pieces of no. 22 wire around the spreader and the antenna wire. The spreaders are spaced about 18 inches.

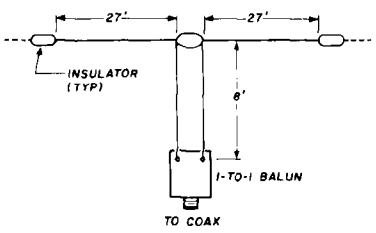
An easy way to make the line is to stretch two 10-foot lengths of wire

FIGURE 3



High-pass filter designed to attenuate TV interference from cordless telephones operating in 49 to 50 MHz region.

FIGURE 4



Compact 7/21 MHz antenna attributed to G3TKN. The 8-foot stub is made of no. 22 enamel coated wire, spaced 6 inches.

under tension between two fixed supports, about waist high. The spreaders are threaded on the wires and fastened in position. When the two-wire line is cut loose, it should be straight and taut.

The antenna is strung up in a straight line, or in an inverted V. An SWR curve should be run across each band, with the maximum indication less than 2:1. The SWR curve can be modified a bit by trimming or lengthening the wires in the stub.

Make sure your coax connection at the balun is waterproof to protect the line from internal moisture and corrosion.

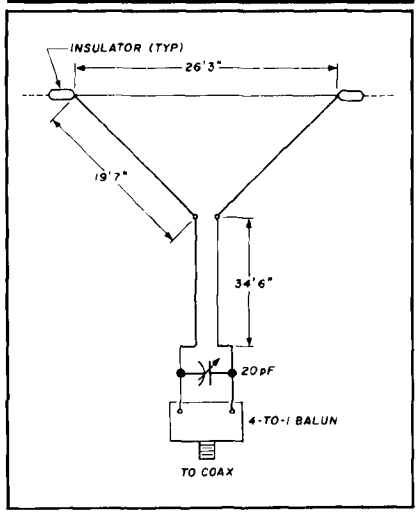
A delta loop for 7, 10, 14, 18, 21, 24, and 28 MHz

In a few months we'll finally have the 18-MHz band! This means there will be seven bands available between 7 and 29.7 MHz. It's time to think about a seven-band antenna.

Why not try a center-fed antenna about 66 feet long in conjunction with a two-wire, balanced transmission line and an antenna tuner? How about using a delta loop in the same fashion (**fig. 5**)? This particular design (attributed to Willi Richartz, HB9ADQ) is popular with many European stations. It's a loop configured so that the point of maximum current falls in the center of the top wire on the 7, 14, 21, and 28-MHz bands. If the open-wire feedline is cut to length as indicated, the loop may be fed on these bands with a 4:1 balun; no auxiliary tuner is required. A 20-pF capacitor is placed across the antenna feedpoints at the balun. It can be a ceramic or mica unit, or made up of a short length of 300-ohm line trimmed on a capacitance meter.

If you want to operate on 18 or 24 MHz, the antenna must be fed from a balanced tuner at the point where the balun would be attached. The radiation pattern is a figure eight, at right angles to the plane of the loop. On 20 meters and the higher frequency bands, the loop provides a small gain over a dipole. For best operation, the top wire of the loop should be about 30 feet above ground.

FIGURE 5



The HB9ADQ multiband delta-loop antenna. The feedline consists of no. 16 wire, spaced 4 inches. Spreaders are spaced 16 inches. Alternatively, 300-ohm ribbon line may be used, with an antenna tuner substituted for the 4:1 balun.

More 88-mH inductors!

I just received a note from Ed Wetherhold, W3NQN (102 Archwood Avenue, Annapolis, Maryland 21401), telling me he has a quantity of 88-mH inductors suitable for use in audio filters and networks. If you're interested, send an SASE to Ed at the above address for more information.

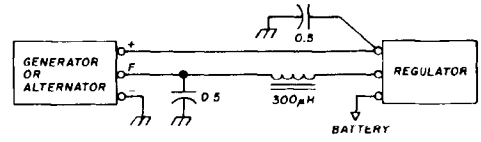
Alternator or generator noise

A growing number of Amateurs are operating HF mobile after a lull in this activity for many years. There's still a problem with automobile electrical system noise, and some mobile operators are troubled by alternator or generator noise during reception.

In general, most alternator/generator noise or "whine" can be reduced (but not necessarily eliminated) by placing a 0.5-μF coaxial capacitor on the output, or armature lead. Bypassing the field lead is, however, another matter. "Conventional wisdom" warns not to bypass this lead, or you may harm the voltage regulator unit.

Don Sutherland, ZL2AJL, takes exception to conventional wisdom in this case. He says the field wire may be bypassed to ground to eliminate noise, if the proper precautions are taken (**fig. 6**). A 300-μH ferrite-core RF choke capable of carrying the field cur-

FIGURE 6



Alternator-generator noise may be substantially reduced by addition of filters, as shown in this simplified circuit. Capacitors are ordinary metal-cased "generator condensers." The 300-μH choke must be capable of carrying the field current. (Circuit courtesy ZL2AJL.)

rent is placed in the lead, and the generator/alternator field wire is bypassed at the case of the unit. He says you'll have no difficulty with contact erosion in mechanical regulators, even with the relatively large value of bypass capacitor on the field lead, provided that you include the RF choke between the capacitor and the regulator. He notes that a British firm, Joseph Lucas (makers of automotive electrical equipment), has recommended this suppression technique for many years. Don says he developed the technique independently, with no knowledge of Lucas' prior work in that field.

The "Dead Band" Contest

Amazing, my dear Watson! More and more faithful readers of this column have correctly identified the quotation from the Sherlock Holmes story, "A Study in Scarlet." The sleuths include: Gerry Skloot, KE2N; Howard Tooker, W3TL; Ben Richardson, WB1CUA; Louis Axeman, Jr., N8LA; Dan Deckert, WA6FQC; Mike Mahoney, WA1KNO; and Chris Kirk, KA1RSV.

Since you're all such a smart bunch, Ed Wetherhold, W3NQN, offers this quiz: name the book, author, and the person to whom this quote is directed — "Call me Ishmael." Good luck!

Article C **HAM RADIO**



Wideband Preamp 10-1000 Mhz

Dual GasFet low noise preamplifier for HF, UHF or VHF systems. Just perfect for the R-7000. Excellent for Spec Analyzers, Scanners, etc. Gain 20 Db +/- 1 DB, -3 Db at 2 & 1100 Mhz. 1 Db compression of >10 Dbm. Intercept points >45 Dbm. New shipped price of only $124.95. Pa. residents please add 6% state tax.

GTI Electronics
RD 1 BOX 272
Lehighton, Pa. 18235
717-386-4032

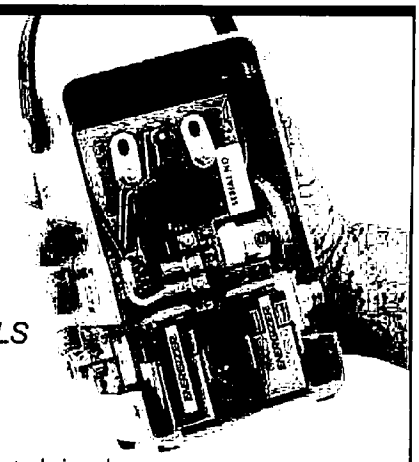
124

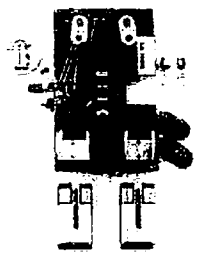
NEW

New Mod Kit for Bird Model 43 Wattmeter

MEASURES PEAK POWER OF SSB AND OTHER AM SIGNALS

Bird Model 4300-400 modification kit quickly adapts any Bird Model 43 Wattmeter to measure audio peak power of single sideband and other AM modulated signals.





The 4300-400 kit pc board mounts inside the Model 43 housing, on the meter studs. Estimated conversion time is only 15 minutes from start to finish.

Once modified, you can measure peak power to an 8% F.S. accuracy, without affecting cw operation or accuracy.

And, the Model 4300-400 is surprisingly inexpensive. Contact your Bird distributor or factory for details.

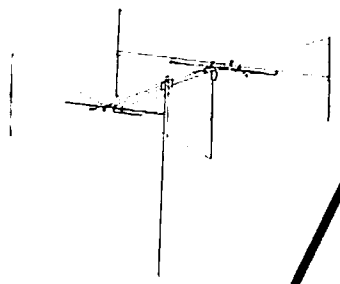
BIRD Electronic Corporation

30303 Aurora Rd., Cleveland (Solon), Ohio 44139 — 2794
216-248-1200 TLX: 706898 Bird Elec UD FAX: 216-248-5426
WESTERN REGION OFFICE
Bird Electronic Corp
621 Ojai Ave., Suite F, P.O. Box 28, Ojai, CA 93023 805-646-7255

123

HF ANTENNAS FROM BUTTERNUT

The HF4B "Butterfly"™
A Compact Beam
for 20-15-12-10 Meters



- Unique design reduces size but not performance
- No lossy traps; full element radiates on all bands
- Retrofit kit for 17 meters coming soon
- Turns with TV rotor
- Only 17 lbs

Butternut Verticals

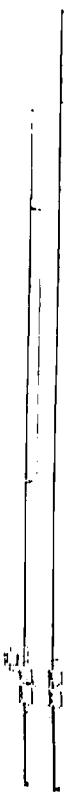
Butternut's HF verticals use highest-Q tuning circuits (not lossy traps!) to outperform all multiband designs of comparable size!

Model HF6V

- 80 thru 10 (5 and 10 meters automatic bandswitching)
- Add-on kit for 12 and 17 meters available now
- 20 ft tall

Model HF2V

- Designed for the low band DXer
- Automatic bandswitching on 80 and 40 meters
- Add-on coils for 160 and 30 or 20 meters
- 40 feet tall, may be top loaded for additional bandwidth



For more information see your dealer or write for a free brochure

BUTTERNUT ELECTRONICS CO
105 East Market Center Point, Texas 78644



THE HAM NOTEBOOK

Two in one: trace doubler for CRO, and square wave and pulse generator

My circuit (using one quad two-input NAND gate 4011 and one dual op amp LM358) is a simple, low cost, and easy-to-operate trace doubler for CROs. Other uses include: electronic switching, supplying blanking pulses for the z-axis of CROs, keying and synchronizing slave-type multivibrators and trigger circuits, adjusting the component values of CRO probes, and quick checking the frequency responses of amplifiers.

Circuit and working principle

The trace-doubler circuit is shown in fig. 1. IC1a, IC1b, and IC1c of the quad two-input NAND gate 4011 are connected as an astable multivibrator; IC1d is connected as an inverter. Terminals 3 and 11 of the 4011 give square waves with opposite phases. The square waves (e_p) at the output of IC1a, passing through differentiator C_4R_{13}, then form positive and negative pulses (e_t). The dual op amps of the LM358 are used as two gated amplifiers for the two signals e_1 and e_2 and fed through terminals 2 and 6, to be displayed simultaneously on the CRO screen.

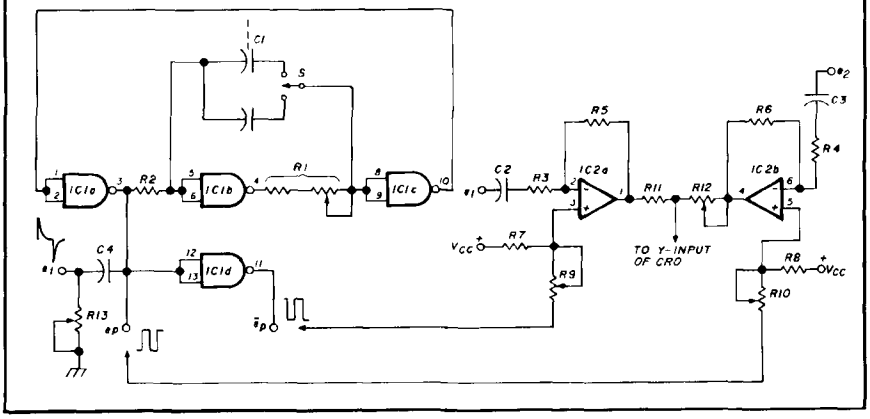
The two opposite-phase square waves e_p and $\bar{e}_p$ are used to gate IC2a and IC2b at terminals 3 and 5 of the LM358, respectively. Resistances R_9 and R_{10} are preadjusted so that one op amp is driven to saturation while the other works normally as an amplifier. Thus they will amplify the two signals e_1 and e_2 alternately, and two separate traces will be displayed on the screen. Resistance R_{12} can be varied to adjust

PARTS LIST

Parts List (fig. 1)

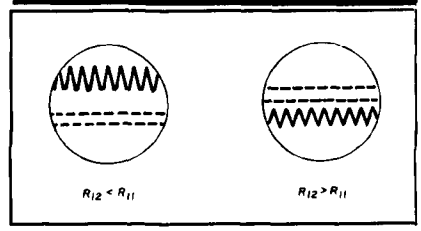
IC1	4011	R3	20k
IC2	LM358	R4	20k
		R5	200k
C1	0.001 μF	R6	200k
	0.01 μF	R7	50k
	0.1 μF	R8	50k
	1.0 μF	R8	50k pot
	10 μF	R10	50k pot
C2	25 μF	R11	100 ohm
C3	25 μF	R12	300 ohm pot
C4	0.001 μF	R13	50k pot
R1	500-ohm + 50-k pot	Vcc	6 volts
R2	500 ohm	S	multipole switch

FIGURE 1



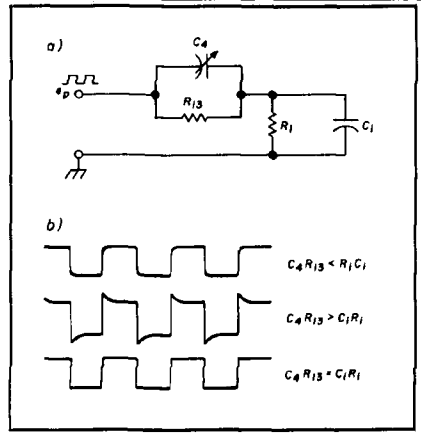
Circuit of the trace doubler for CRO, and square waves and pulse generator.

FIGURE 2



Oscillograms of the displayed input signals e_1 (sine wave) and e_2 (square wave).

FIGURE 3



(A) Probe adjusting circuit for CRO. (B) Displayed square waves on CRO screen.

the vertical separation of the two traces.

Select a suitable value of C_1 with switch S and adjust the pot of R_1. The frequency of square waves can be varied from 1 cps to 10^6 cps. This process is necessary for stabilizing the waveforms displayed on the screen.

A common supply of 6 volts is used in the circuit.

Practical examples

1. **Figure 2** shows the oscillograms of the displayed input signals e_1 (sine wave) and e_2 (square wave).
2. **Figure 3A** is the probe adjusting circuit for CRO; **fig. 3B** shows the oscillograms of the displayed square waves of e_p at three different values of R_pC_p. R_1 is the input resistance of the CRO and C_j is the input capacitance.

By Tseng C. Liao, Peking, China

Calibrating series-resistance capacitance bridges

Bridges like the series-resistance capacitance type shown in **fig. 1** are easy to build and operate. But there seems to be some confusion about how to calibrate C_1 to indicate the correct load reactance. This confusion seems to result from the fact that there is a fixed capacitor C_2 in the load branch, and the signs in the formula used to determine the load reactance are opposite to those you'd expect.

On the series-resistance capacitance bridge, C_2 is necessary because it permits nulling the bridge (zero load reactance) with C_1 set to the mid-position — namely, $C_1 = C_2 = 70$ pF. A capacitively reactive ($-X_x$) load allows nulling the bridge by reducing the capacitance of C_1; an inductively reactive ($+X_x$) load requires that C_1 be increased in value to do so. The equivalent series reactance ($\pm X_x$) of the unknown load impedance (Z_x) is the difference in the setting of C_1 between the initial balance when X = 0 ($C_1 = 70$ pF) and the load reactance, or

$$X_x = \frac{1}{2\pi F}\left(\frac{1}{C_1'} - \frac{1}{C_1''}\right)$$

where

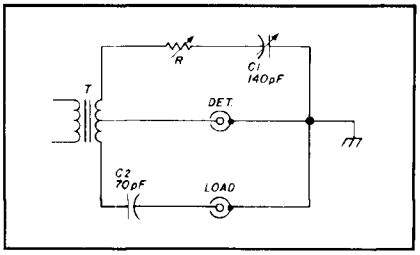
C_1' is the first reading of $C_1 = 70$ pF

C_1'' is the second reading of C_1 with the load

F is the test frequency.

A + sign indicates that X_x is capacitive, while a − sign corresponds to an inductive X_x. This appears to be a contradiction, but remember that C_1 is in the opposite branch of the bridge. To obtain the proper sign for the load reactance, simply reverse the sign in the answer.

FIGURE 1

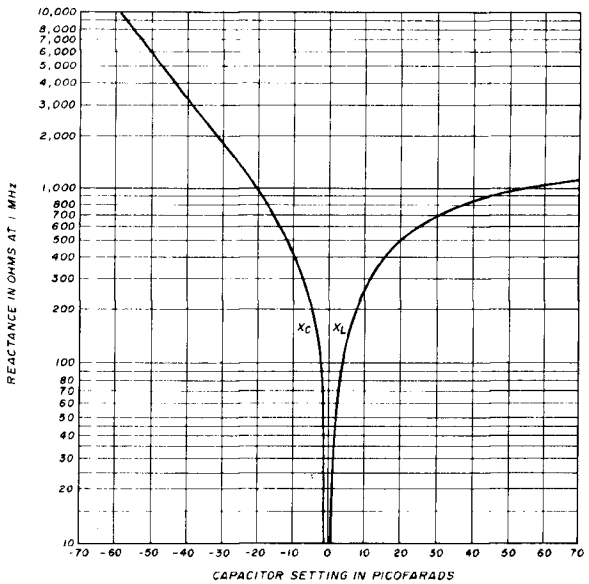


Basic schematic of series-resistance-capacitance bridge.

A reactance plot of the capacitance of C_1 is shown in **fig. 2** using eqn. **1** and a frequency of 1 MHz. To obtain the reactance at higher frequencies, divide the reactance for 1 MHz by the test frequency. The reactance plot is calibrated in capacitance in several steps from −70 pF through 0 pF to +70 pF, as shown.

In the event that C_1 is some value other than 140 pF, C_2 must be one-half that of C_1. A smaller variable capacitor will limit the useful reactance range of the bridge; a larger variable capacitor will reduce the accuracy of the bridge. The calibration procedure remains the same.

FIGURE 2



Calibration curve for reactance.

Wilfred N. Caron,
Ridgecrest, California 93555
Article D

SHORT CIRCUIT HOTLINE

Building a current *ham radio* project? Call the Short Circuit Hotline any time between 9 AM and Noon, or 1 to 3 PM — Eastern time — *before* you begin construction. We'll let you know of any changes or corrections that should be made to the article describing your project.

(See "Publisher's Log," April, 1984, page 6, for details.)

603-878-1441

STRUCTURAL EVALUATION OF YAGI ELEMENTS

By Dick Weber, K5IU, P.O. Box 44, Prosper, Texas 75078

Try this simple analysis procedure

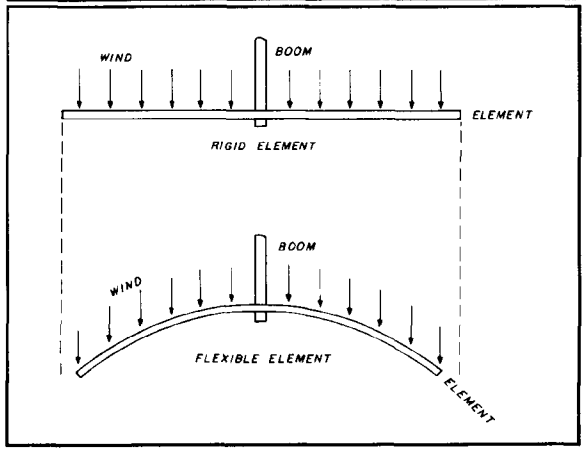
Over the past year or so, I've been working on a design procedure for developing structurally sound Yagi elements. I spent many hours with Bob Mitchell, N5RM, analyzing the structural integrity of his "Forty-Meter Flame Thrower"[1] and developing the first steps of my procedure. After I completed my initial work, Gerald Williamson, K5GW, used the process to design the elements of two full-size 40-meter beams which are stacked on his rotating tower. He also used it to build his shortened-element 80-meter beam and is now designing a full-size 80-meter beam.

In late spring of 1987, I heard that Dick Fenwick, K5RR, had several identical Yagis elements break in high winds. I asked Dick to send me a sketch of the elements that failed, but not to tell me where they broke. After entering the data into my analysis program and letting it run, I found the element's weakness. Dick confirmed the correctness of my "after the fact" prediction. The elements of his identical beams failed at the exact spot the program indicated. This procedure should help you evaluate the mechanical integrity of your existing designs or design a homebrew Yagi.

Failure modes

An element has failed if it breaks off or is bent enough to render it useless. There are several causes of in-service failures. The element could be covered with too much ice, the wind hitting the element may impose a load which causes it to fail, or the element may break off because of wind-induced vibration or fluttering. The first two causes have to do with direct loading of the element due to ice and wind; the third generally happens at very low wind speeds. My procedure deals only with the loading of the element, *not* with vibration-induced fatigue failures.

FIGURE 1



Graphic illustrations of both the Rigid Element Model and the Flexible Element Model, and how each reacts to a theoretical wind.

The environment and survivability

To determine survivability, give careful consideration to the Yagi's environment. The main environmental problem is loading due to ice and wind. The weight of the ice loads the element and its thickness increases the element diameter. The increased diameter of the element results in a higher wind load.

You must make several choices when designing or evaluating an element. It's necessary to determine or select the extreme ice and wind conditions the element will have to handle. Consider whether the element is expected to survive those conditions, or have an additional margin of safety. Some manufacturers state their

design will survive specific wind speeds. In a strict engineering sense, survivability means that if the stated conditions are exceeded, there will be a failure. If there is a margin of safety, failure will occur at conditions of higher severity. It's wise to understand all aspects of the loads on an element, the materials used in its construction, and their safety factors. Without this, you could construct an element that costs and weighs more than it needs to survive its environment. This design might place unnecessarily higher loads on the tower and rotator.

Element analysis

You can mathematically construct two element models. I call them the Rigid Element Model (REM) and the Flexible Element Model (FEM). REM is an approximation of the more exact and complex FEM version. The REM model assumes the element doesn't deflect when loaded with ice or wind. It also assumes that all parts of the element are perpendicular to the wind. FEM accounts for the deflections of the element at all points along its length. The actual element length exposed to the wind decreases as it deflects. **Figure 1** shows the REM and FEM assumptions applied to an element. With FEM, the wind loading isn't perpendicular to the element at all points. This decreases the loading on the element as compared to REM. The wind loading of the element is less severe with FEM, but more accurate.

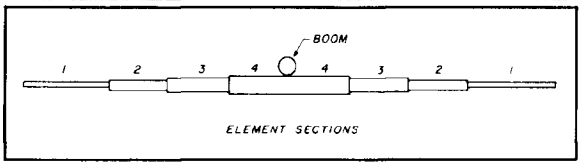
While the FEM version gives a precise description of the actual conditions, modeling is complex and time consuming. REM is easier and faster. The errors introduced by the REM assumptions result in a design more conservative than one using FEM.

General approach

Begin your element analysis by selecting the wind and ice conditions it is to survive and calculating the loads these conditions will place on the element. The loads are related to the element's size. You must know the relationship between the wind, ice, and tubing sizes used in the element to find the resulting loads. Once you've determined the loads, find the resulting stress by ascertaining the type of material used to make the element along with its geometric properties. Compare the stress to the maximum allowable value for the material used. If the resulting stress is lower than the maximum acceptable level, the design is conservative. If the stress is over the maximum acceptable level, the design won't survive the wind and ice conditions.

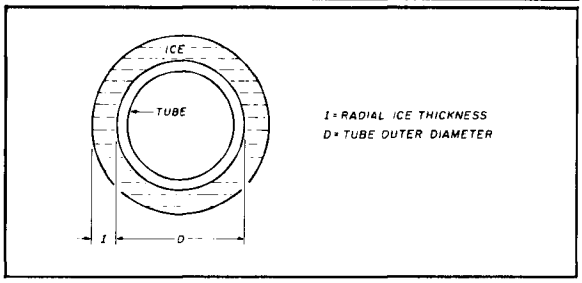
You can identify weak spots when analyzing an existing design or compare it with the relative merit of others. If an existing design is weak, you may choose to reinforce it or purchase another. When planning an element, you can alter the design by using different sizes and lengths of tubing in the element makeup until you find an acceptable combination.

FIGURE 2



A typical Yagi element constructed from telescoping sections of aluminum tubing.

FIGURE 3



Yagi element shown with "ice loading." If you know the tube outer diameter and the thickness of the ice on the element, you can closely approximate the amount of loading being placed on the element.

Element description

Figure 2 shows a typical element constructed from various tubing sizes. The outermost element section is called 1; the numbers increase as they approach the boom. Because the element is symmetrical relative to the boom, the other half of the element will have the same numbering scheme. An element section is a part of the element that has the same outer diameter and wall thickness. If one part of the element telescopes into another, a new section is formed. A section can be long or short, but its entire length must have the same wall thickness and outer diameter. If a tube is reinforced either on the outside or inside, a new section is created because its geometric properties are different. **Figure 2** shows a four-section element. Because the sections are the same on both sides of the boom, the analysis procedure will be applied only to one.

Element loading

There are three components to the loading of an element: the weight of any ice on the element section, the weight of the tubing making up the section, and the wind load on the section. They must be determined and summed to yield the total loading. The first step is to break the element into sections as shown in **fig. 2**. Then find the total load on each individual section.

Two types of ice can form on the element. The most common is solid ice; the least common is rime ice. My equations are based on solid ice weight. Solid ice weighs 56 pounds per cubic foot, rime ice about 30 pounds per cubic foot.[2] Generally, ice accumulation

on round tubes is stated in terms of "radial thickness." For example, if a 1-inch diameter tube has 0.25 inch of radial ice, the effective diameter for the wind loading is 1.5 inches. The inch weight is determined by the volume of ice surrounding the tube as shown in **fig. 3.**

For solid ice, Wi can be found using **eqn. 1.**

$$Wi = 0.102 \times L(D \times I + I^2) \quad (1)$$

Wi = weight of ice on section (pounds)
I = radial ice thickness (inch)
L = section length (inch)
D = tube outer diameter (inch)

To find the tubing weight in a section take one of two approaches. Either look up the weight of the tubing in a supplier's catalog or calculate it directly. The weight per foot is given on most tubing charts. Calculating the weight directly may be easiest because this method doesn't depend on having a catalog. Because most Yagi elements are made from aluminum tubing, use **eqn. 2** to find the section weight. This ignores the weight of the tubing inside the overlap of two telescoped sections.

$$Wa = 0.31 \times L(D \times T - T^2) \quad (2)$$

Wa = weight of aluminum tubing section (pounds)
T = tubing wall thickness (inch)
L = section length (inch)
D = tube outer diameter (inch)

The last load on the element section is wind induced. When the wind strikes a surface, pressure is created by the impact of the air stream on the surface. The wind load depends mainly on the wind velocity and the shape of the impacted surface; some shapes are more or less streamlined than others. Use **eqn. 3** to find the wind load on a round tubing section. The drag coefficient is included in the equation to account for the streamlined effect of a round tube,[2] along with the conversion of units for wind pressure.

$$Fw = 0.0047 \times L \times De \times P \quad (3)$$

Fw = wind load on round section (pounds)
L = section length (inch)
P = wind pressure perpendicular to a flat surface (pounds/square foot)
De = effective outer diameter of tube (inch)

The effective diameter of the tube (De) accounts for an increase in diameter due to ice. If there's no ice, the tube's outer and effective diameter are the same.

$$De = D + I + I \quad (4)$$

De = effective outer diameter of tube (inch)
I = radial ice thickness (inch)
D = tube outer diameter (inch)

The total load on a section (Ft) is the sum of the ice weight, element weight, and wind load.

$$Ft = Wi + Wa + Fw \quad (5)$$

Ft = total load on section (pounds)
Wi = weight of ice on section (pounds)
Wa = weight of aluminum tubing section (pounds)
Fw = wind load on section (pounds)

You could argue that the two weights added together are at right angles to the wind load and shouldn't be added directly. There's no guarantee that this will be the case; upward and downward wind streams are a common occurrence.[3]

Wind pressure

Calculate the wind pressure striking a flat surface with **eqn. 6.**[2] This isn't the wind pressure on a round tube, but a flat surface. **Equation 3** includes a "drag coefficient" to alter the wind pressure found in **eqn. 6. Equation 6** also includes a gust factor of 1.30 to account for short duration gusts peaking above the mean speed of V. If you select a wind speed and use **eqn. 6**, you are actually calculating for a wind speed 1.30 times higher. For example, when you select a wind speed of 86.6 mph, you are actually accounting for a peak wind of 112.6 mph.

$$P = 0.004 \times V^2 \quad (6)$$

P = wind pressure on flat surface with 1.30 gust factor (pounds/square foot)
V = wind speed (miles/hour)

If you don't want to use a gust factor, you can modify **eqn. 6** to find the wind pressure at the exact wind speed entered. Removing the gust factor gives you **eqn. 7.**

$$P = 0.0024 \times V^2 \quad (7)$$

P = wind pressure on flat surface (pounds/square foot)
V = wind speed (miles/hour)

What's the proper wind load an element should be expected to handle? You can make the selection in several ways. Research the history of wind speeds in your area. Go back about 20 to 50 years to see what the worst wind has been. Find out if the wind information should have the gust factor applied.

Consult local building codes covering towers and similar structures. EIA standard RS 222c contains information on the wind loading towers should be designed to handle, based on their geographical location. You can also consult the American Standard Building Code. Both EIA RS 222c and the American Standard Building Code include maps of the United States recommending design wind loads. There are small differences between the codes, but for Amateur applications they are basically the same.

According to RS 222c, most of the United States should expect a 50-year mean reoccurrence wind of 86.6 mph. Certain coastal areas have a 100 mph or higher recommendation. The wind speeds found in EIA RS 222c are mean wind speeds, and are to be used with **eqn. 6.** The most common wind speed is 86.6 mph; 100.0 and 112.0 mph are the extreme values. **Table 1** shows wind pressures at various mean wind speeds and their corresponding peak value with a 1.30 gust factor.

Because the REM procedure errs on the conservative side, using a mean wind speed of 86.6 mph results in a conservative design for most areas and would be a rigid

TABLE 1

Wind pressures at various mean wind speeds and their corresponding peak value with a 1.30 gust factor.

Mean Wind Speed (mph)	Corresponding peak wind with 1.30 gust factor (mph)	Wind pressure (pounds/square foot)
20.0	26.0	1.6
30.0	39.0	3.6
40.0	52.0	6.4
50.0	65.0	10.0
60.0	78.0	14.4
70.0	91.0	19.6
80.0	104.0	25.6
86.6	113.0	30.0
100.0	130.0	40.0
112.0	145.6	50.0
115.0	149.5	52.9
125.0	162.5	62.5

TABLE 2

Calculate the worst combinations of conditions in your area for winter and non-winter conditions to evaluate existing design. Numbers shown are for my QTH.

Season	Radial ice	Mean wind	Peak wind	Pressure level
Winter	0.25 inch	40.0 mph	52 mph	6.4 pounds/square foot
Non-winter	0 inch	86.6 mph	113 mph	30 pounds/square foot

TABLE 3

Dimensions for half of a 36-foot Yagi element with four sections as in *fig. 2*.

Section	L (inch)	D (inch)	T (inch)
1	48.0	0.500	0.058
2	60.0	0.625	0.058
3	72.0	0.750	0.058
4	36.0	0.875	0.058

TABLE 4

Winter conditions

Section	Wi (pounds)	Wa (pounds)	Fw (pounds)	Ft (pounds)
1	0.92	0.39	1.45	2.76
2	1.34	0.61	2.04	3.99
3	1.83	0.90	2.71	5.44
4	1.04	0.53	1.49	3.06

TABLE 5

Non-winter conditions

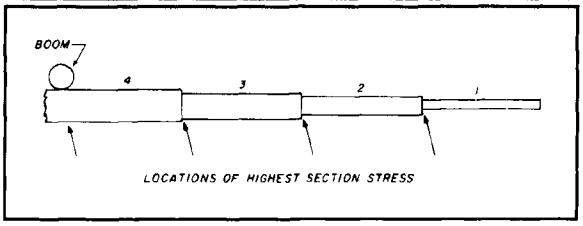
Section	Wi (pounds)	Wa (pounds)	Fw (pounds)	Ft (pounds)
1	0	0.39	3.38	3.77
2	0	0.61	5.29	5.90
3	0	0.90	7.61	8.51
4	0	0.53	4.44	4.97

standard by which to evaluate existing designs. Judge the expected amount of radial ice and, more importantly, the combination of wind and ice for your own area and make your evaluations based on these sets of conditions. Here in northern Texas, our highest winds occur in the spring and early summer. We often have ice storms in the winter, but the winds are not very high. At my location I use the two sets of conditions in **table 2**; yours may be quite different.

Loading example

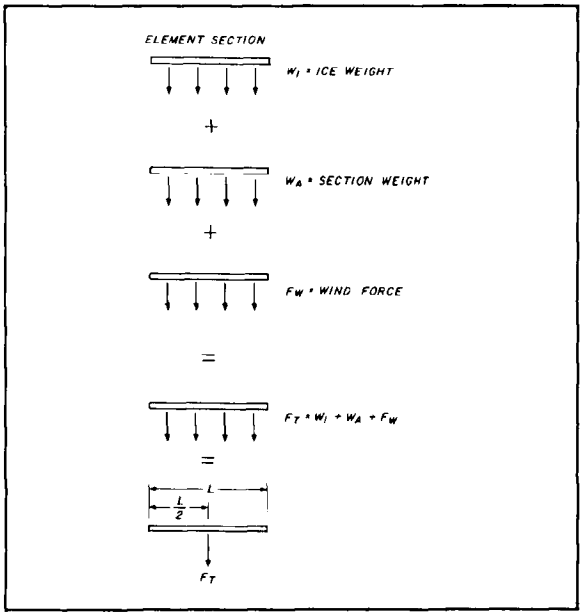
Table 3 gives the dimensions for half of a 36-foot Yagi

FIGURE 4



The joints where progressive sections of an element telescope together are typically the high stress points along the element.

FIGURE 5



Shown here are the three individual distributed forces, the total distributed force, and the total force applied at the element's "center of action."

element with four sections like those in **fig. 2. Tables 4** and **5** show the loads Wi, Wa, Fw, and Ft for the winter and non-winter conditions in **table 2**. Comparing the Fts for both cases shows the non-winter conditions to be much more severe than the winter ones. Because the non-winter conditions are the most severe, only they will be used in the last stages of the element analysis. When confronted with several sets of conditions, determine which are the most severe and use them in your analysis.

The stress in a section varies along the section length. The highest value occurs at the point where one section ends and another begins, as you approach the boom. In this analysis procedure, you'll calculate only the highest stress value in each section. **Figure 4** shows the locations under the greatest stress in a four-section element.

The forces resulting from wind, ice weight, and element weight of each section are evenly distributed over the section's length. The three evenly distributed forces can be replaced by a point force (Ft) applied at a unique location. The location is at the "center of action" — the section's midpoint. **Figure 5** shows the three individual distributed forces, the total distributed force, and the total force applied at its center of action. You need Fts and their points of application to find the maximum stress in the sections.

Fts cause the element to bend; this results in bending stresses in the tube sections. These stresses are calculated from the geometry of the tube and the amount of bending action. Use **eqn. 8** to find the bending stress when you know the section modulus of the tube and the bending moment at the point of interest. There is another stress at this point, but it's very small and will be ignored.

$$Sb = \frac{M}{Z} \qquad (8)$$

Sb = bending stress (pounds per square inch, psi)
M = bending moment (pound per inch)
Z = section modulus (inch^3)

The section modulus for a round tube (Z) can be found using **eqn. 9**.

$$Z = 0.098 \times \frac{D^4 - (D - 2T)^4}{D} \qquad (9)$$

Z = section modulus (inch^3)
D = tube outer diameter (inch)
T = tube wall thickness (inch)

The section modulus describes the geometry of the tube. If you consider tubes of the same material, the one with the larger section modulus can take additional bending. To find the section modulus for two or more close-fitting telescoped tubes, make the combined wall thickness T and the largest outer diameter D. **Table 6** gives the section moduli for a number of tube sizes. **Table 7** gives the section moduli for various telescoped combinations.

In table **7**, the combined wall thickness of 0.116 inch is for two walls of 0.058 inch; the combined wall thickness of 0.174 inch is for three walls of 0.058 inch. The values shown are for standard telescoping combinations. For example, an 0.875 inch outer diameter tube with a combined wall thickness of 0.174 inch is made of three telescoped tubes. It has 0.875, 0.750, and 0.500-inch diameter tubes, each with a wall thickness of 0.058 inch.

To find the bending moment you must know the forces causing the bending and the distances to their points of application. The forces are the Fts found for each section; the distances are taken from the location of the section midpoints. **Figure 6A** shows the situation for section 1. Find the moment at the point of maximum stress in section 1 with **eqn. 10**.

$$M1 = Ft1 \times \frac{L1}{2} \qquad (10)$$

TABLE 6

Section moduli and weights for a number of tube sizes.

Tube outer diameter (inch)	Wall thickness (inch)	Weight per foot (lbs/ft)	Section modulus (inch³)
0.25	0.035	0.03	0.0011
0.25	0.049	0.04	0.0013
0.25	0.058	0.04	0.0014
0.375	0.049	0.06	0.0036
0.375	0.058	0.07	0.0040
0.50	0.058	0.01	0.0080
0.50	0.125	0.17	0.0115
0.625	0.058	0.12	0.0134
0.625	0.125	0.23	0.0208
0.75	0.058	0.15	0.0202
0.75	0.125	0.	0.0332
0.875	0.058	0.18	0.0285
0.875	0.120	0.34	0.0474
1.00	0.058	0.20	0.0382
1.00	0.125	0.40	0.0670
1.125	0.058	0.23	0.0492
1.125	0.125	0.46	0.0885
1.25	0.058	0.26	0.0618
1.25	0.125	0.52	0.1130

TABLE 7

Section moduli for various telescoped combinations.

Tube outer diameter (inch)	Combined wall thickness (inch)	Section Modulus (inch³)
0.375	0.116	0.0051
0.500	0.116	0.0112
0.500	0.174	0.0120
0.625	0.116	0.0202
0.625	0.174	0.0230
0.750	0.116	0.0319
0.750	0.174	0.0379
0.875	0.116	0.0465
0.875	0.174	0.0570
1.000	0.116	0.0639
1.000	0.174	0.0803
1.125	0.116	0.0841
1.125	0.174	0.1078
1.250	0.116	0.1072
1.250	0.174	0.1395

M1 = moment in section 1 (pound-inch)
Ft1 = total load on section 1 (pounds)
L1 = length of section 1 (inch)

Using the non-winter conditions of **table 5**, calculate the bending moment and bending stress for section 1 as follows:

From **table 5**, Ft1 = 3.77 pounds
From **table 3**:
L1 = 48.0 inches
D1 = 0.500 inch
T1 = 0.058 inch
and then from **table 6**
Z1 = 0.0080 inch³
Using **eqn. 10**

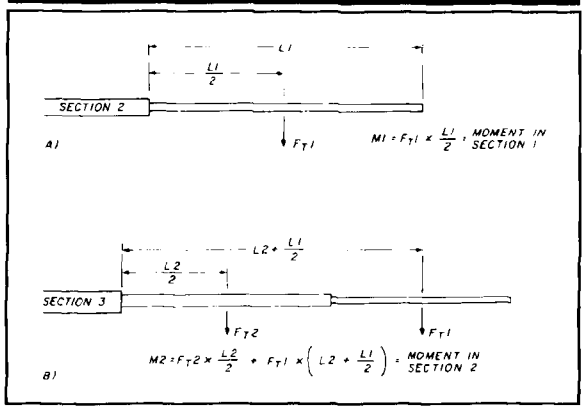
$$M1 = 3.77\ pounds \times \frac{48.0}{2}\ inch = 90.5\ pound\text{-}inch$$

Using the bending moment and the section modulus (Z1) calculate the bending stress using **eqn. 8.**

$$Sb1 = \frac{90.5\ pound\text{-}inch}{0.0080\ inch^3} = \frac{11{,}312.5\ pounds}{inch^2}$$
$$Or\ 11{,}312.5\ psi$$

Sb1 = bending stress for section 1 (pounds per square inch)

FIGURE 6



(A) Determining the moment for section one of the element. (B) Determining the moment for section two, and showing how the moment of the previous section(s) are added together for each new section calculated.

To find the bending moment at the highest stress point in section 2, multiply the appropriate Fts by the distance from their centers of action to the highest stress point and then add them together. **Figure 6B** shows the forces and distances. M2 is the sum of the moments produced by Ft1 and Ft2.

$$M2 = Ft2 \times \frac{L2}{2} + Ft1 \times \left(L2 + \frac{L1}{2}\right) \quad (11)$$

M2 = bending moment at end of section 2 (pound-inch)
Ft2 = section 2 total load (pounds)
Ft1 = section 1 total load (pounds)
L1 = section 1 length (inch)
L2 = section 2 length (inch)

Find the stress in section 2 with **eqn. 8** using the moment at the point of highest stress and the section modulus at that point.

$$Sb2 = \frac{M2}{Z2}$$

Continuing with the values from **table 3** and the non-winter case from **table 5**, the variables are as listed:

L1 = 48.0 inches
L2 = 60.0 inches
Ft1 = 3.77 pounds
Ft2 = 5.91 pounds
D2 = 0.625 inch
T2 = 0.058 inch
Z2 = 0.0134 inch^3 (from **table 6**)

$$M2 = 5.91\,pounds \times \frac{60.0}{2}\,inch + 3.77\,pounds \times$$

$$(60.0\,inch + \frac{48.0}{2}\,inch)$$

M2 = 177.3 pound-inch + 316.7 pound-inch = 494.0 pound-inch

$$Sb2 = \frac{M2}{Z2} = \frac{494.0\,pound\text{-}inch}{0.0134\,inch^3} = 36{,}865.6\,PSI$$

If there are three sections, M3 is calculated from:

$$M3 = Ft3 \times \frac{L3}{2} + Ft2 \times \left(L3 + \frac{L2}{2}\right)$$

$$+ Ft3 \times \left(L3 + L2 + \frac{L1}{2}\right)$$

$$Sb3 = \frac{M3}{Z3}$$

If there are four sections, M4 is calculated from:

$$M4 = Ft4 \times \frac{L4}{2} + Ft3 \times \left(L4 + \frac{L3}{2}\right)$$

$$+ Ft2 \times \left(L4 + L3 + \frac{L2}{2}\right)$$

$$+ Ft1 \times \left(L4 + L3 + L2 + \frac{L1}{2}\right)$$

$$Sb4 = \frac{M4}{Z4}$$

If there are more than four sections, the method is expanded following the same pattern. Use what follows as a guide.

The highest stress in a section is determined by finding the bending moment at the point of highest stress and dividing it by the section modulus of the tube at that point. The bending moment is found by multiplying the forces (Fts) causing the bending at the point of highest stress by the corresponding distance to their points of application and then summing.

At this point, it's easier to either write a program to do all the math, or do it by hand in tabular form. **Table 8** shows the complete solution set for the example being used.

The maximum stress in each section has been calculated and must be compared to the allowable maximum. There are three popular aluminum alloys used in commercial Yagis and by Amateur builders. The maximum allowable stress for each is shown in **table 9**. The most commonly used alloy, 6061-T6, is found in most commercial Yagis; it can be obtained from supply houses and mail-order outlets.

The maximum allowable stress is usually called the "yield stress." Exceed this stress level and the part may break or be permanently bent. If you go beyond this level only slightly, you may not notice the bend because of the existing element droop. But if you greatly exceed the stress level, your element may incur a large, permanent bend or break. In this situation, a hidden safety factor

TABLE 8

Complete solution set.

Sec	OD (in)	T (in)	L (in)	Ft (lbs)	Z (in³)	M (lbs-in)	Sb (psi)
1	0.500	0.058	48.0	3.77	0.0081	90.5	11,300
2	0.625	0.058	60.0	5.90	0.0134	494.0	36,860
3	0.750	0.058	72.0	8.51	0.0202	1496.3	74,070
4	0.875	0.058	36.0	4.97	0.0285	2240.2	78,600

TABLE 9

Maximum allowable stress for the three popular aluminum alloys used in commercial Yagis and by Amateur builders.

Aluminum Alloy	Maximum allowable stress (psi) (4)
6061-T6	35,000
6063-T6	25,000
6063-T83	30,000

TABLE 10

Element with section lengths altered to obtain maximum allowable stress.

Sec	OD (in)	T (in)	L (inl	Ft (lbs)	Z (in³)	M (lbs-in)	Sb (psi)
1	0.500	0.058	84.0	6.59	0.0081	276.7	34,580
2	0.625	0.058	24.0	2.36	0.0134	463.2	34,500
3	0.750	0.058	24.0	2.84	0.0202	712.0	35,130
4	0.875	0.058	84.0	11.69	0.0285	2189.0	76,720

TABLE 11

Element with section 4 a telescoped combination 1.00 and 0.875-inch diameter tube.

Sec	OD (in)	T (in)	L (in)	Ft (lbs)	Z (in³)	M (lbs-in)	Sb (psi)
1	0.500	0.058	84.0	6.59	0.0081	276.7	34,580
2	0.625	0.058	24.0	2.36	0.0134	463.2	34,500
3	0.750	0.058	24.0	2.84	0.0202	712.0	35,130
4	1.000	0.116	84.0	14.51	0.0640	2311.5	36,110

may come into play. If the maximum allowable stress is just slightly surpassed, you may not have a failure resulting in element breakage. The only result may be a slight permanent bend, which may not be observable or cause any harm. This safety factor would come into play if the peak wind conditions were exceeded.

The example in table **8** shows that, regardless of the alloy used, this design is over stressed in two areas. In addition, it's marginal in one area and acceptable in another. Using 6061-T6 aluminum throughout this example, the maximum allowable stress is 35,000 psi. Any section stress below this value indicates a section which is not fully utilized; any section stress above the maximum value indicates a section which is overloaded. An overloaded section must be changed to bring the stress level down to an acceptable level. You'll have equal strength when all section stresses have the same value. There are good reasons to have some sections stronger than others, but this is an economic decision to be discussed later.

What can be done to improve the example element in table **8**? Make the 0.500 diameter tube longer to take more load and reduce the length of others while keeping the total length the same. Lengthening the 0.500 diameter tube to allow it to take more load also reduces the total wind load put into the element because the smaller diameter tubing is replacing the larger. Table **10** shows the same element with altered section lengths. Starting at the outer section and working towards the boom, the section lengths were changed to obtain the maximum allowable stress.

Sections 1, 2, and 3 are acceptable; 4 is still unacceptable. There will be slight improvement if you use more of the lighter, less expensive tubing. Section 4 still has a problem, but has improved somewhat. With the smaller sections optimized, improvement in section 4 is impossible without a change in its geometry. Table **11** shows the same element, with section 4 as a telescoped combination of 1.00 and 0.875-inch diameter tubes.

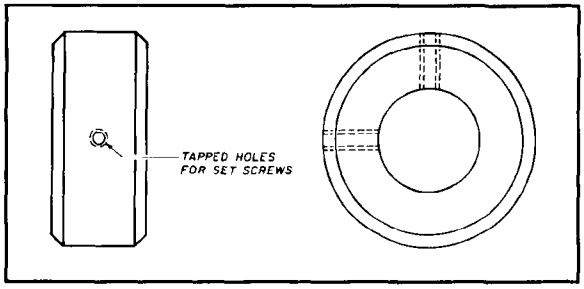
Section 4 has a stress slightly over the maximum. This

TABLE 12

Example of section 4 shown as a single tube with marginal strength.

Sec	OD (in)	T (in)	L (in)	Ft (lbs)	Z (in³)	M (lbs-in)	Sb (psi)
1	0.500	0.058	84.0	6.59	0.0081	276.7	34,580
2	0.625	0.058	24.0	2.36	0.0134	463.2	34,500
3	0.750	0.058	24.0	2.84	0.0202	712.0	35,130
4	1.250	0.058	84.0	16.60	0.0619	2399.4	38,780

FIGURE 7



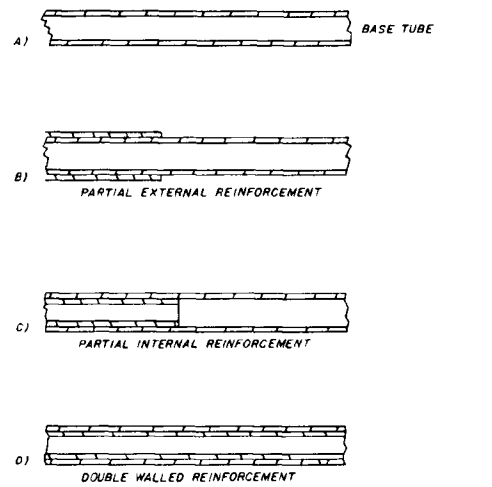
Description of a spacer which can be used when making a large decrease in tubing sizes on an element; i.e., two sizes that will not telescope together and allow a compression joint.

design is totally acceptable given the conservative nature of the rigid element model. There are several things to note. As the element gets longer, the strength requirements rapidly increase. This can be seen by the very short lengths of sections 2 and 3. In addition, section 4 had to be drastically reinforced. **Table 12** shows the same example, where section 4 is a single tube with marginal strength. Section 4 is a 1.250-inch diameter tube of 0.058-inch wall thickness. This large tube has about the same section modulus as the composite of the 1.000 and 0.875-inch tubes, but has a larger wind load due to its larger diameter. This offsets some of its greater load bearing capacity.

You'll encounter a problem when making a large jump in tubing size. Because the jump from 0.750 to 1.250 isn't a telescoping fit, you need to fabricate a spacer or "donut." **Figure 7** shows a spacer used by N5RM to build his 40-meter flame thrower.[1] Several manufacturers swage the end of a larger tube to a smaller size. The result is a large diameter reduction allowing a telescoping fit with a smaller tube. This method is not practical for the individual builder.

There are several ways to achieve a significant increase in section strength. One is to try increasingly larger diameter tubes in your calculations, until you find an outcome with an acceptable stress. This could lead to a fabrication problem due to non-telescoping tubing sections. You can also increase the strength of a section by externally or internally reinforcing the tube along part or all of its length. **Figure 8** shows three reinforcement methods. In doing the analysis, you will create a new section when there is a change in the tube geometry.

FIGURE 8



Several methods for reinforcing element tubing are shown: At (A) the base tube with no reinforcing, at (B) the base tube with partial external reinforcement, at (C) the base tube with partial internal reinforcement, and at (D) the base tube as used in a double walled reinforcement.

Figures 8A and **8D** are one section while **figs. 8B** and **8C** are two sections. The method you select should be based on cost, ease of construction, availability of materials, total element weight, and total element wind area. There are a large number of possible combinations of tubing sizes which can be successfully used in a design. The final configuration depends on your resources and ingenuity.

It's desirable to have a design with no weak links, but having links of differents strengths can be good and bad. It depends on what you want the design to accomplish. If you want the absolutely lightest element, design sections with the same maximum allowable stress. This design may not provide an economical use of tubing; it's usually purchased in finite lengths, and sections may be wasted. Zero waste may not be possible unless you make it a design consideration from the beginning. You could try to put together an element without cutting tubing which could be used for another project. In this case the section stresses might be quite different. This is totally acceptable provided none exceed the maxi-

TABLE 13

Tubing sizes of a 36-foot element with poor design.

	EWT = 8.4 pounds		EWL = 68.4 pounds	
Section	**D (inch)**	**T (inch)**	**L (inch)**	**Sb (psi)**
1	1.000	0.058	48.00	4,760
2	1.125	0.058	96.00	35,050
3	1.250	0.058	72.00	64,910

TABLE 14

36-foot element with improved design.

	EWT = 8.0 pounds		EWL = 66.4 pounds	
Section	**D (inch)**	**T (inch)**	**L (inch)**	**Sb (psi)**
1	1.000	0.058	131.00	35,450
2	1.125	0.058	13.00	33,220
3	1.250	0.058	18.00	33,700
4	1.250	0.116	54.00	35,830

TABLE 15

Comparison of materials used in *Tables 13* and *14*.

	Case 1 (Table 13)		**Case 2 (Table 14)**	
Tube Diameter size (0.058 wall)	**12-foot lengths needed**	**waste**	**12-foot lengths needed**	**waste**
1.000	1	38 inches	2	16 inches
1.125	2	86 inches	1	0 inches
1.250	1	0 inches	1	0 inches

mum allowable stress. You can use different alloys of tubing as long as you don't exceed the maximum allowable stress level for each type.

The section nearest the boom will be the most expensive and minimum waste is a goal. Make section 1 from the least costly tubing. It can give you the largest span for the least money. Look closest at the intermediate sections for waste. Several other considerations mentioned earlier come into play when making tradeoffs between tubing sizes and reinforcement methods. Consider the overall element weight and area. If there is choice between several options, the lighter, smaller area element offers some advantages. If two designs for a four-element, 20-meter beam were found to have acceptable stress levels, choose between them on basis of the amount of wind load they put into the tower and rotator. Because using REM requires finding the weight and wind load of each section, it would be easy to sum the total section weights and wind loads to obtain two other parameters for comparing element designs. Multiply these by 2 to obtain the total for both element halves.

EWT = 2 × (sum of all section Was) **(12)**
= total element weight (pounds) ignoring overlap

EWL = 2 × (sum of all section Fws) **(13)**
= total wind load on element (pounds) at maximum wind speed

I found the element design in **table 13** in an Amateur publication. The tubing sizes for this 36-foot element show that it is a very strong one. Or is it? With the analysis done at 86.6 mph and no ice, this element was found to be poor and the end of section 3 to be very weak. Section 1 could be made a lot longer. I found an acceptable configuration after I made several attempts to improve this design using the same tube sizes. **Table 14** shows the improved design.

Section 1 was greatly lengthened, while section 2 was greatly reduced. Section 3 was changed to a shorter section. The new section 4 is the remainder of the old section 3, reinforced on the inside with some of the same material used in section 2. Not only has the strength of the element improved, but there has been a slight drop in element weight and wind load. Was this an efficient use of the material? **Table 15** shows the materials used and the waste for the two cases. This was done assuming a 5-inch overlap at each joint and stock tubing lengths of 12 feet. You can make several conclusions when comparing the published design and improved version by looking at

TABLE 16

Revised element for improved design.

	EWT = 7.3 pounds		EWL = 42.8 pounds	
Section	**D (inch)**	**T (inch)**	**L (inch)**	**Sb (psi)**
1	0.500	0.058	84.00	34,580
2	0.625	0.058	24.00	34,500
3	0.750	0.058	23.00	34,550
4	0.750	0.116	30.00	34,640
5	1.00	0.116	55.00	34,730

TABLE 17

Summary of features of element designs in *Tables 16, 13,* and *14*.

	Table 16	**Table 13**	**Table 14**
Survival mean wind speed (peak) (mph)	86.6 (112.5)	64.0 (83.2)	86.6 (112.50)
Element weight (pounds)	7.3	8.4	8.0
Element wind load at 86.6 mph (pounds)	42.8	68.4	66.4

tables 13, 14, and **15**. The improved version is lighter, less expensive to build, places less wind load on the tower, and is significantly stronger.

Take care not to generate a design with a hidden problem. The example in **table 11** is a buildable design, but has a construction problem. Section 4 is 84 inches long. This is not half of a 12-foot piece where 6 feet are used on each side of the boom. Using the 84-inch section results in a lot of waste, and requires special efforts for mounting and joining at the boom. A design revision uses a piece of section 2 material for internal reinforcement. Two 12-foot telescoped pieces are cut to a length of 110.0 inches with half on each side of the boom. **Table 16** shows the improved design.

Table 17 summarizes the features for the element designs in **tables 16, 13,** and **table 13**'s improved version in **table 14**. This improvement costs less and is slightly lower in weight and wind load. The element in **table 16** will withstand the same wind, but have about **35** percent less wind load. You can build Yagis which minimize the loads placed on towers, booms, and rotators, while still surviving very high winds.

Before using this method of element design, determine your constraints, limitations, and objectives. The procedure allows you to generate designs to minimize weight and wind loading, and make optimal use of materials. It can be used to evaluate any existing design.

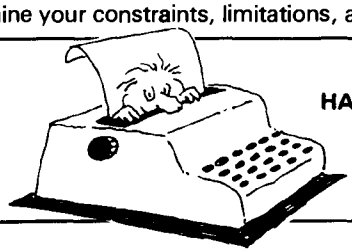
Summary

This analysis procedure provides a simple and sound method to evaluate the structural integrity of existing element designs and assist in the process of designing an element. I have presented several methods of reinforcing element sections and various criteria by which to judge them. To implement the procedure, you'll need to determine the *worst set of survival conditions for your geographical location*, your objectives, and restrictions.

References

1. R.H. Mitchell, N5RM, "The Forty-Meter Flame Thrower, A 3-Element 40-Meter Beam," *CQ*, December 1987, page 36.
2. "RS 222c, Structural Standards for Steel Antenna Towers and Antenna Supporting Structures," Electronic Industries Association, March 1976.
3. C.J. Richards, et al., "Mechanical Engineering in Radar and Communications," D. Van Nostrand Reinhold Company, 1969, page 150.
4. Alcoa Handbook of Design Stresses for Aluminum, Aluminum Company of America, 1966, page 92.

Article E **HAM RADIO**



INVITATION TO AUTHORS

HAM RADIO welcomes manuscripts from readers. If you have an idea for an article you'd like to have considered for publication, send for a free copy of the **HAM RADIO** Author's Guide. Address your request to **HAM RADIO**, Greenville, New Hampshire 03048 (SASE appreciated).

FORMATTED DISPLAY OF PACKETS USING KISS

By Michael Pechura, WA8BXN, CIS Department, Cleveland State University, E. 24th at Euclid Avenue, Cleveland, Ohio 44115

Format your packets for readable display

In the October issue, I talked about the basics of displaying the information found in individual packet radio packets using KISS mode. You'll recall that KISS sends raw packet frames from the TNC to a computer as a set of bytes, without interpreting the header or other content of the packets.

This month I'll look at packet format and how to display the various fields in a readable form. I'll also discuss BASIC programs that can be run on either a C-64 or an IBM PC computer.

Each packet consists of two major portions: the header and the data (which may be absent). When operating in KISS mode, the TNC sends a packet to the computer by starting with a byte that is **C0** in hex, followed by a byte that is usually zero. This is followed by all the bytes of a packet and finally ends with another byte of hex **C0**.

The TNC mmakes the following replacements to avoid problems with packets that themselves contain bytes of hex **C0**. A byte of hex **C0** found in a packet to be sent to the computer is replaced by 2 bytes, **DB DC**. A byte of hex **DB** found in a packet is replaced by **DB DD**. This solves the transparency problem. When the computer receives either of these byte pairs from the TNC, it must replace them with the corresponding single byte to get the actual packet content.

For example, if a packet actually contained the data bytes **DA DB DC DD** the computer would receive the following from the TNC: **DA DB DD DC DD**.

As I've already mentioned, a packet contains two major parts: the header and the data portion. For some packets, the data portion isn't used. Within the header there are also two parts: the address and the command byte. The address contains the calls of the sending and receiving stations as well as the calls of any digipeaters used. The command byte tells what kind of packet it is along with sequence number information for some types. The relation of these fields is shown below:

Packet			
Header		Data	
Address bytes	Command Byte	PID	Data Bytes

The address bytes consist of two or more fields, each 7 bytes long. The first two fields give the destination and origination callsign, respectively. Call these the "tocall" and "fromcall." Any additional fields give digipeater callsigns (the "VIA" list). Thus for the address bytes we have:

Address bytes			
tocall	fromcall	digicall	digicall

Within each of these callsign fields, the first 6 bytes give the callsign. The last byte gives, among other things, the – ##(WA8BXN-**01**) often found after calls. This byte is called the Secondary Station ID (SSID). These callsign fields can't be printed as ASCII characters as they are found in a packet, because some encoding is done.

The first 6 bytes of each callsign field containing the callsign are each shifted left 1 bit position, making the right bit of each byte equal to zero. If the callsign has less than 6 characters, blanks (also shifted left one bit position) are added on the right to make a total of 6 bytes. The SSID byte also has the SSID number shifted left 1 bit. All these bytes are shifted left one bit position to make room for the bit that indicates the end of the

address bytes. All but the rightmost address byte will have a zero bit in its rightmost bit position. The rightmost address byte has a one bit in its rightmost bit position signaling the end of the address bytes.

Callsign field in address	
6-byte callsign shifted left one bit	SSID byte

The use of the bits in the SSID byte depend on which callsign it's associated with -- the to/from calls or digipeater calls. In both cases the SSID number bits are found in the same place:

Bit Positions							
7	6	5	4	3	2	1	0
			SSID number				0

Because the SSID number is a 4-bit number, it can have values of 0 through 15. Callsigns with an SSID number of zero generally don't show the -0. The rightmost bit of the SSID byte is zero for all SSID bytes (and callsign bytes) except for the last one. Thus the end of the address field of a packet is indicated by a one bit in the rightmost bit of an SSID byte. Bits 5 to 7 of an SSID byte have different meanings. For example, bit 7 in the SSID byte is used with digipeater calls. When set to 1 it means that a digipeater has repeated the packet.

The "tocall" of WA8BXN-3 is an example of a callsign field. The hex for the ASCII representation of WA8BXN is **57 41 38 42 58 4E**. Each of these bytes must be shifted left one bit position. Because the ASCII coding of characters uses only 7 bits, no information is lost by this left shift. The W (01010111 in binary) becomes hex **AE** (10101110 in binary). The SSID number (3) in binary is 0011. Thus we have:

W	A	8	B	X	N	-3	
AE	82	70	84	B0	9C	06	Encoded callsign

If this had been the last callsign in the address, the SSID byte would have been **07**. If this was the digipeater call of a digipeater that repeated this packet, the SSID byte would be **86** (or **87** if it was the last digipeater).

There are three basic kinds of command bytes for the three kinds of packets. The rightmost 1 or 2 bits of the command byte indicate the type of packet:

Command Byte							
							0 Information frame
						0	1 Supervisory frame
						1	1 Unnumbered frame

The use of the remaining bits in the command byte depends on the packet type. In the case of an Information frame (I), there are two sequence numbers and a Poll bit. The sequence numbers are N(S), the sequence number of this frame, and N(R), the sequence number of the next I frame expected in reply. The sequence numbers take on values of 0 through 7 and then repeat. Use of the Poll bit varies; its value will be displayed later.

N(R)	Poll	N(S)	0	
				Information frame

There are three kinds of Supervisory frames; all are used to acknowledge receipt of I frames. Each contains an N(R) sequence number; i.e., the sequence number N(S) expected in the next I frame received. This acknowledges reception of all lower numbered I frames. A Poll/Final bit is also found in the command byte. It, too, will be displayed later.

N(R)	P/F	0	0	0	1	
N(R)	P/F	0	1	0	1	Receive Ready (RR)
N(R)	P/F	1	0	0	1	Receive Not Ready (RNR)
						Reject (REJ)

The final command type (Unnumbered) has the most variations. The majority of them have to do with connecting and disconnecting. This group also contains beacon transmission information. In each command byte of this group the rightmost 2 bits are both 1s, indicating that it's a U frame. Five bits are used to specify the particular command. They are split into groups of 3 bits and 2 bits with a Poll and/or Final bit in between them.

0	0	0	P/F	0	0	1	1	Unnumbered Information
0	0	0	F	1	1	1	1	Disconnected Mode
0	0	1	P	1	1	1	1	Set Async Balanced Mode
0	1	0	P	0	0	1	1	Disconnect
0	1	1	F	0	0	1	1	Unnumbered Acknowledge
1	0	0	F	0	1	1	1	Frame Reject

With 5 bits to specify the particular function to be done, there could be as many as 32 different functions. Only the 6 given above are typically used in packet radio. Unnumbered Information frames contain data bytes following the command. These frames are often used for beacons and are sent when a TNC is used in Converse mode, while not connected to another station.

Some of these commands are often used in pairs. For example, to establish a connection the Set Asynchronous Balanced Mode (SABM) command is sent. The expected reply to this is Unnumbered Acknowledge (UA). If the station to which the SABM is sent doesn't wish to enter into a connection, the reply will be Disconnected Mode (DM). This usually causes a "Busy" message to be displayed.

Disconnect (DISC) is sent to terminate a connection. The reply to this is normally UA.

The last of the Unnumbered frame types is Frame Reject (FRMR). This packet type is sent when an error is detected that can't be corrected by simply resending an improperly received frame. Three data bytes that try to indicate what went wrong follow the command byte.

The last packet field requiring some explanation, contains the data bytes. Data bytes are found only in I frames and UI frames. The data field contains a Protocol Identifier (PID) byte followed by zero or more actual data bytes. Normally the PID is **F0** in hex. Other PID values may be used by some variations of the standard protocol. A PID of hex **CF** is used between NET/ROMS nodes, for example.

This short explanation of the fields found in packets gives the basic information you need to understand what the program displays. A more complete description of the AX.25 protocol is found in the book *AX.25 Amateur Packet-Radio Link-Layer Protocol*, published by the ARRL. This book discusses how these fields are used and the way they inter-relate to each other, along with details on their format.

The program presented in this article gives you another way to understand how all these formats and commands fit together. It lets you watch the packets in action, with all the fields displayed in a readable fashion. The only thing you can't see are the CRC bytes in the packets. These are checked by the TNC and not made available to the computer.

I've provided two versions of the program — one for the IBM PC (and clones) in **fig. 1** and one for the C-64 in **fig. 2**. Both are very similar so the program discussion applies to either. They've been written for use with a Kantronics TNC that has been set up for operation at 600 baud between the TNC and computer.

I minimized the program comments in the interest of increased speed and reduced typing. The program can be divided into the following sections:

Lines	Purpose
20 — 30	Initialize serial port and screen colors. In IBM PC version, substitute COM1 or COM2 where appropriate.
40	Put TNC in KISS Mode. Modify or delete as needed for non-Kantronics TNCs.
50	Wait for beginning of frame (hex **C0** = 192 decimal).
60	Get & ignore 0 byte, print separator line.
70	Clear string TXT$ (will be used in later addition).
80	Get & print tocall < ---from call.
90 — 120	Get & print digipeater list.
140	Get command byte.
150	If other than I frame continue at 270.
160 — 170	Display I frame command fields.
180	Get & display PID byte in hex.
190	Get & test next byte. If hex **C0** it's end of frame, so go back to 50 to wait for next packet.
200 — 250	If data byte is printable, print as character. If not, then line 250 displays it in Hex in a different color. The C-64 version swaps capital and lower case letter codes to make them appear right on the screen.
280 — 330	If it's a Supervisory frame, print fields of command then continue at line 190 to print any data found (there shouldn't be any).
350 — 430	Display Unnumbered frame's command name and P/F bit. If frame is UI frame, go to line 180 to show PID and data. Otherwise go to line 190 to read hex **C0** byte that ends frame.
450 — 490	Subroutine to read 6 bytes of callsign (shifting each right 1 bit by dividing by 2) and print them. SSID number is extracted from 7th byte read and printed if not zero.
500 — 550	Wait for byte to arrive from TNC then read it. If it's one of the special pairs (**DB DC** or **DB DD**) return the single byte for which they appear.
560	Print the number in A as two hex characters.

After typing the appropriate version of the program into the computer, be sure to save it before you proceed. If you find and correct any syntax errors, save the program again before running. Before running the program make sure the TNC is set up for 600 baud operation to the computer.

The following is representative of what you should see as output from the program. The actual number of characters per line seen on the screen will be different from the lines lengths used here. Those data bytes that aren't printable as characters are represented instead as two hex digits, displayed in a different color from other data bytes.

```
--------------------------------
WA8XXX<--K8XXX: UNNUMBERED FRAME
UNNUMBERED ACKNOWLEDGE F=0
--------------------------------
WA8XXX<--K8XXX: SUPERVISORY
FRAME  N(RCV)=1 P/F=0  RECEIVE READY
--------------------------------
BEACON<--AX6X: UNNUMBERED FRAME
UNNUMBERED INFORMATION P/F=0  PID=F0
: AX6X HIGHLAND HTS — BBS AX6X-20D
--------------------------------
W8XXX<--KX8XX: INFO FRAME  N(RCV)=0
P=0  N(SENT)=1  PID=CF: 9688p8
E86@ AEpA298B2@a@02FB000003
```

FIGURE 1

```
10 REM DISPLAY PACKETS USING KISS --- IBM PC VERSION (600 BAUD)
20 CLOSE 2:COLOR 7,0,0: CLS
30 OPEN "COM2:600,N,8,1,CS,DS,CD" AS 2: H$="0123456789ABCDEF"
40 PRINT#2,"KISS ON"+CHR$(13)+"RESET"
50 GOSUB 500:IF A<>192 THEN 50
60 GOSUB 500: PRINT "----------------------------------------"
70 TXT$=""
80 GOSUB 450: PRINT "<--";: GOSUB 450
90 IF (A AND 1)=1 THEN 120
100 PRINT " VIA ";
110 GOSUB 450: IF (A AND 1)=0 THEN PRINT ",";: GOTO 110
120 PRINT ": ";
130 REM
140 GOSUB 500: REM GET COMMAND BYTE
150 IF A AND 1 THEN 270 ELSE REM ITS AN INFORMATION FRAME
160 P=(A AND 16)/16:PRINT "INFO FRAME  N(RCV)=";INT(A/32);" P=";P;
170 PRINT " N(SENT)=";(A AND 14)/2;
180 GOSUB 500: PID=A : PRINT " PID=";: GOSUB 560: PRINT ": ";
190 GOSUB 500: IF A=192 THEN PRINT: GOTO 50
200 IF PID=207 THEN TXT$=TXT$+A$
210 IF A<32 OR A>126 THEN 250
220 IF A>=65 AND A<=90 THEN PRINT A$;: GOTO 190
230 IF A>=97 AND A<=122 THEN PRINT A$;: GOTO 190
240 PRINT A$;: GOTO 190
250 COLOR 1: GOSUB 560: COLOR 7: GOTO 190
260 REM
270 IF A AND 2 THEN 350 ELSE REM ITS A SUPERVISORY FRAME
280 PRINT "SUPERVISORY FRAME  N(RCV)=";INT(A/32);"P/F=";P;
290 SS = (A AND 12)/4
300 IF SS=0 THEN PRINT " RECEIVE READY";
310 IF SS=2 THEN PRINT " RECEIVE NOT READY";
320 IF SS=3 THEN PRINT " REJECT";
330 GOTO 190
340 REM
350 PRINT "UNNUMBERED FRAME  ";: B=(A AND 12)/4 + (A AND 224)/8
360 IF B=7  THEN PRINT "CONNECT REQUEST P=";
370 IF B=8  THEN PRINT "DISCONNECT REQUEST P=";
380 IF B=3  THEN PRINT "DISCONNECTED MODE F=";
390 IF B=12 THEN PRINT "UNNUMBERED ACKNOWLEDGE F=";
400 IF B=17 THEN PRINT "FRAME REJECT F=";P;":";
410 IF B THEN PRINT P;: GOTO 190
420 PRINT "UNNUMBERED INFORMATION P/F=";P;: GOTO 180
430 PRINT "UNKNOWN TYPE ";: GOSUB 560: PRINT " P/F=";P;"";: GOTO 190
440 REM
450 FOR I=1 TO 6:  REM MAKE A CALLSIGN PRINTABLE
460 GOSUB 500: A=INT(A/2):IF A<>32 THEN PRINT CHR$(A);
470 NEXT I
480 GOSUB 500: B=(A AND 30)/2:IF B THEN PRINT -B;
490 RETURN
500 A$=INPUT$(1,2) :REM GET BYTE FROM TNC
510 IF A$=""THEN A$=CHR$(0)
520 A=ASC(A$):IF A<>219 THEN RETURN
530 A$=INPUT$(1,2)
540 IF ASC(A$)=220 THEN A$=CHR$(192): A=192: RETURN
550 A$=CHR$(219):A=219: RETURN
560 PRINT MID$(H$,INT(A/16)+1,1)+MID$(H$,(A AND 15)+1,1);:RETURN
```

IBM PC version.

FIGURE 2

```
10 REM DISPLAY PACKETS USING KISS --- C-64 VERSION (600 BAUD)
20 CLOSE 2:PRINT CHR$(147)+CHR$(5)+CHR$(14):: POKE 53280,
   0:POKE 53281,0
30 OPEN 2,2,3,CHR$(7):H$="0123456789ABCDEF":GET#2,A$
40 PRINT#2,"KISS ON"+CHR$(13)+"RESET"
50 GOSUB 500:IF A<>192 THEN 50
60 GOSUB 500: PRINT "----------------------------------------"
70 TXT$=""
80 GOSUB 450: PRINT "<--";: GOSUB 450
90 IF (A AND 1)=1 THEN 120
100 PRINT "VIA ";
110 GOSUB 450: IF (A AND 1)=0 THEN PRINT ",";: GOTO 110
120 PRINT ": ";
130 REM
140 GOSUB 500: REM GET COMMAND BYTE
150 IF A AND 1 THEN 270 ELSE REM ITS AN INFORMATION FRAME
160 P=(A AND 16)/16:PRINT "INFO FRAME  N(RCV)=";INT(A/32);" P=";P;
170 PRINT " N(SENT)=";(A AND 14)/2;
180 GOSUB 500: PID=A : PRINT " PID=";: GOSUB 560: PRINT ": ";
190 GOSUB 500: IF A=192 THEN PRINT: GOTO 50
200 IF PID=207 THEN TXT$=TXT$+A$
210 IF A<32 OR A>126 THEN 250
220 IF A>=65 AND A<=90 THEN PRINT CHR$(A OR 32);: GOTO 190
230 IF A>=97 AND A<=122 THEN PRINT CHR$(A AND 223);: GOTO 190
240 PRINT A$;: GOTO 190
250 PRINT CHR$(158);: GOSUB 560:PRINT CHR$(5);: GOTO 190
260 REM
270 IF A AND 2 THEN 350 ELSE REM ITS A SUPERVISORY FRAME
280 PRINT "SUPERVISORY FRAME  N(RCV)=";INT(A/32);"P/F=";P;
290 SS = (A AND 12)/4
300 IF SS=0 THEN PRINT " RECEIVE READY";
310 IF SS=2 THEN PRINT " RECEIVE NOT READY";
320 IF SS=3 THEN PRINT " REJECT";
330 GOTO 190
340 REM
350 PRINT "UNNUMBERED FRAME  ";: B=(A AND 12)/4 + (A AND 224)/8
360 IF B=7  THEN PRINT "CONNECT REQUEST P=";
370 IF B=8  THEN PRINT "DISCONNECT REQUEST P=";
380 IF B=3  THEN PRINT "DISCONNECTED MODE F=";
390 IF B=12 THEN PRINT "UNNUMBERED ACKNOWLEDGE F=";
400 IF B=17 THEN PRINT "FRAME REJECT F=";P;":";
410 IF B THEN PRINT P;: GOTO 190
420 PRINT "UNNUMBERED INFORMATION P/F=";P;: GOTO 180
430 PRINT "UNKNOWN TYPE ";: GOSUB 560: PRINT " P/F=";P;"";: GOTO 190
440 REM
450 FOR I=1 TO 6:  REM MAKE A CALLSIGN PRINTABLE
460 GOSUB 500: A=INT(A/2):IF A<>32 THEN PRINT CHR$(A);
470 NEXT I
480 GOSUB 500: B=(A AND 30)/2:IF B THEN PRINT -B;
490 RETURN
500 IF PEEK(667)=PEEK(668) THEN 500 :REM GET BYTE FROM TNC
510 GET#2,A$:IF A$=""THEN A$=CHR$(0)
520 A=ASC(A$):IF A<>219 THEN RETURN
530 IF PEEK(667)=PEEK(668) THEN 530
540 GET# 2,A$:IF ASC(A$)=220 THEN A$=CHR$(192): A=192: RETURN
550 A$=CHR$(219):A=219: RETURN
560 PRINT MID$(H$,INT(A/16)+1,1)+MID$(H$,(A AND 15)+1,1);:RETURN
```

C-64 version.

KX8XX<--W8XXX: SUPERVISORY FRAME N(RCV) = 2 P/F = 0 RECEIVE READY

ID<--WB8XXX: UNNUMBERED FRAME UNNUMBERED INFORMATION P/F = 0 PID = F0: Network node (CLE)0D

KA8XXX-1 <--WB8XXX: SUPERVISORY FRAME N(RCV) = 1 P/F = 0 RECEIVE READY

BEACON<--KX3X VIA K3XXX: UNNUMBERED FRAME UNNUMBERED INFORMATION P/F = 0 PID = F0: Mail for: NWPAWX ALL DX KX3X NETROM N3XXX VE3XXX0D

WA8XXX<--K8XXX: INFO FRAME N(RCV) = 1 P = 0 N(SENT) = 1 PID = F0: ok0D

WA8XXX<--K8XXX: UNNUMBERED FRAME DISCONNECT REQUEST P = 0

NX8X<K8XXX: UNNUMBERED FRAME CONNECT REQUEST P = 0

WA8XXX<--K8XXX: INFO FRAME N(RCV) = 3 P = 0 N(SENT) = 0 PID = F0: ka = po of!0D

WA8XXX<--K8XXX: SUPERVISORY FRAME N(RCV) = 4 P/F = 0 RECEIVE READY

WA8XXX<--K8XXX: UNNUMBERED FRAME DISCONNECT REQUEST P = 0

Most of this information can be displayed using the monitor commands found in most current TNCs, without your having to do any programming. The point of this program isn't so much to provide a way to display such information, but rather to show how it can be done — and relate what's in a packet to what's displayed.

Many program modifications are possible. I strongly suggest that you run it without modification first. One of your initial additions to the program might be to put an asterisk after the call of the station that actually sent the packet (the one that was heard when digipeater calls are present in the header). Here's a chance to experiment, to build something new, without any additional expense other than time.

An unreduced copy of the program is available for an SASE. Ed.

Article F **HAM RADIO**



Cushcraft R4 vertical antenna

The Cushcraft R4 vertical antenna is a newly designed version of the popular R3 model. Like the R3, the R4 is a half-wave no-radial design which covers 20, 15, and 10 meters. Unlike the R3, the R4 adds 12 meters to its frequency coverage, and eliminates motorized tuning in favor of a network which provides fully automatic frequency selection. Physically, the R4 is 18-feet long and approximately the same weight as its predecessor. (All hardware is stainless steel.) The R4 also looks different, sporting newer style traps, a capacitive hat, and 4-foot decoupling radials at the base. Maximum power rating is 1800 watts PEP.

Assembly

I found the R4 easy to assemble. Cushcraft's step-by-step instruction sheet was visual, showing the path of least resistance to final set-up without wasting a lot of words. For tools, I used a straight-blade screwdriver, a small wrench, and a steel measuring tape. The only assembly operation requiring patience was the decoupling radial bracket, a 4-piece affair held together by 12 screws. The rest of the job was easy. The most critical part of the antenna, a section lined with traps and stubs, comes fully pre-assembled from the factory. Only three simple measurements were needed during final assembly to "tune" the antenna.

Installation

The R4 is especially suited to places where installing a beam or horizontal dipole would be difficult or visually unacceptable. The antenna is very light in weight (8 lbs.), with only 1.4 square feet of wind-loading surface. Thus, I was able to mount mine on top of a 10-foot TV-mast pipe and clamp it to the chimney with Radio Shack® ratchet mounts. No guys were needed. When mounting on a small-diameter mast, check to make sure the end of the pipe doesn't extend past the mounting sleeve and up into the R4's fiber glass base insulator, since this will detune the antenna. Also, when connecting feedline, use the silicon sealer provided in the hardware pack. Without this, the aluminum UHF connector will eventually corrode, making it impossible to disconnect the coax! Finally, try to mount the antenna up in the clear. The manual warns that close proximity to trees, buildings, feedlines, etc., will upset tuning and degrade performance.

Because the R4 is so easy to assemble and erect, I think it would make a great antenna for portable installations. It quickly breaks into two or three sections for transport, and the decoupling radials (four indestructible mobile-type whips) remove in seconds. Add a telescoping 18-foot mast, and you could be motor-home portable from almost any location!

Performance

The R4 is much simpler to use than the R3, since there are no remote-tuning adjustments to deal with. Band switching is fully automatic. You simply plug in the antenna, and operate.

I conducted my first on-air tests on 20 meters — the band most likely to show any compromise in performance. To keep things interesting, I used relatively low power (a Ten-tec Argosy, 50-watt PEP). I also placed a 20-meter dipole at 55 feet on-line for signal-strength comparisons. My prediction was that the 32-foot dipole would significantly outperform the 18-foot R4 — which had the additional handicap of being parked down between the trees on a single-story roof. However, I was in for a pleasant surprise! After several QSOs, I found both antennas generally performed within one S-unit of each other. While this in no way constitutes reliable "antenna range" testing, it did convince me that any compromise in the R4's performance due to its shorter length is minor, and possibly offset by a more favorable TOA.

Performance on the other bands was equally impressive. For example, I called CQ on a seemingly-dead 15-meter band, and was answered by F5GT, who gave me a 579 report. At noon, 10-meters yielded several good reports from South America.

Next, I ran SWR curves to see how closely this particular antenna, assembled on a picnic table and installed at my less-than-perfect location, matched those provided by Cushcraft. On all bands, I obtained readings of 1.2:1 or better at the point of resonance, with readings below 2:1 at the band edges. However, not all minimum SWR points landed where Cushcraft predicted they would — or in my favorite band segments. Although it will probably have little impact on actual performance, one day I plan to indulge my compulsion to tweak things just a bit closer.

Conclusion

Overall, I found the Cushcraft R4 easy to assemble and install. It's also easy to look at. For those reasons alone, I think it would make a great antenna for apartment, condo, motor-home, or portable use. But, beyond that, I was especially impressed with how well it worked. I think the R4 is a winner and I can recommend it.

K1BQT

DRSI PC*Packet Adapter and software

In twenty years, we'll look back at the '80s as the decade of the computer. Oh sure, they were available earlier, but they were more a curiosity and had limited capacity. Today there's a wealth of different machines available and you can pick and choose.

One of the most popular computer designs is the IBM PC and its various clones. Prices range from less than $800 for a basic 8088 machine to — well the sky's the limit.

Another revolution has occurred in the Amateur field of digital communications. CW and RTTY have been around for years. But Packet Radio (computer to computer communications) has exploded and shows no sign of abating. It was only logical that, sooner or later, someone would mix the two technologies together and come up with a product that includes all the benefits and none of the limitations. One of the biggest complaints many packet users express is that when operating in packet mode, their machine could do nothing else. However, the PC Packet Adapter and controller software can be turned on and then run in a background mode, freeing you to do whatever else you want — without disconnecting from packet. This "running in the background mode" is what distinguishes the PCPA from other packet units.

DRSI's PC Packet Adapter is a plug-in, state-of-the-art, dual-port communications adapter card for the PC/clone computer. The PCPA has a 1200-baud modem for standard VHF/UHF packet operation. It connects directly to your radio through a DB-9 connector. The second port can be configured for either RS-232 or TTL level outputs. You can use the second port for either a HF modem or connection to a high-speed RF modem, among other possibilities.

The PCPA uses a 8530 serial communications controller running at just a hair under 5 MHz. It has flexible addressing and interrupt provisions. The "guts" of the PCPA include a complete 1200-baud modem on a single chip, controlled by the serial communications controller.

Installation is quick and simple. Disconnect all cables, open the computer, install the board, make up a cable to connect the radio to the TNC, put the computer back together and you're done. Total time—15 minutes. The toughest part of the job is wiring the cables; DB-9s are awfully small for my big hands. (Pre-made cables are also available from DRSI.)

The key to the PCPA is the controller's software. The review unit arrived with version 1.0 software. DRSI has since released version 1.2. The program can handle up to 4 connections simultaneously using either version 1 or 2 AX.25 protocol. You'll be interested to know that the software can run both ports at the same time

(continued on page 70)

DECODING DATA SIGNALS

By James A. Sanford, WB4GCS, 20 Glen Forest Drive, Hampton, Virginia 23669

Algorithm improves teletype™ performance in noisy environment

Increasing numbers of Amateurs are involved in data communications. On VHF, many hams use fm transmitters to broadcast via Audio Frequency Shift Keying (AFSK). Direct FSK is the normal mode of transmission on hf.

In the absence of fm, hf data transmission is particularly sensitive to noise — especially at the higher data rates. Packet radio, even with its automatic error correction, is affected by high noise sensitivity. This results in frequent retransmission of packets, slowing the data transmission rate. Packet ensures the information will be correctly received *eventually*. I thought it was possible to do better and looked into ways to minimize this sensitivity.

hardware fixes

An obvious way to improve noise rejection is to modify the hardware used to convert audio signals into pulses for the computer or TTY. Line A of **fig. 1** shows the pulses transmitted to send the letter "R" in Baudot. **Figure 2** is a block diagram of a typical demodulator, similar to the ST-5 or the demodulator used in the PK-232. It consists of a limiter followed by a bandpass filter that removes all signals above and below the mark and space tones. A linear discriminator converts the frequency shift information to varying dc levels. The "slicer", a high-gain comparator, converts the discriminator output levels to discrete pulses which can be used to key a TTY or computer. The circuit is vulnerable to interference from spurious signals between the mark and space frequencies.

Figure 3 shows an improved demodulator. It uses separate filters to select the distinct mark and space frequencies, reducing the vulnerability to spurious signals and improving the signal to noise ratio. Other hardware improvements are possible but difficult, so I turned to improving the computer.

software solutions

The flow chart in **fig. 4** shows how computer programs convert serial data to parallel information for storage and display. The input line is sampled at a rate that is a multiple of the bit rate. For this example, I've chosen a factor of 7. The computer samples the input for a start pulse. If one is present, the computer waits for one-half of the bit time and samples again. If the start bit is still there, the computer accepts this as a valid start pulse rather than noise. Delaying half a bit time puts the sample window near the center of each bit. The computer now delays a whole bit time and samples the input line for the first bit. After another full bit time delay, the computer gets the next bit. This continues until the last bit has been received and the entire character has been assembled. The character is now placed in a buffer to be stored, processed, or displayed. In **fig. 1**, line B shows the sample window. It is shown as a spike because it is so much shorter than the bit time (typically a few microseconds). Line C shows the data as the computer receives it — displaced by one-half bit time. The original pulse relationships and timing are maintained despite the delay. This sampling method resembles that used by hardware serial to parallel converters (ACIAs) like the 6551 and 6850.

In a noise-free system, the pulses emerging from the demodulator are identical to the original. In a noisy environment, the demodulator's discriminator contains noise which can corrupt the slicer's output (even though it's low-pass filtered). Line G of **fig. 1** shows the slicer output, and line H shows what the computer sees — an incorrect character which occurs because the computer looks at such a small window of the total bit time. A single noise pulse can corrupt the data, even though most of the bit is intact. Most Amateur systems waste time between samples; it is possible to use this time to make the computer smarter.

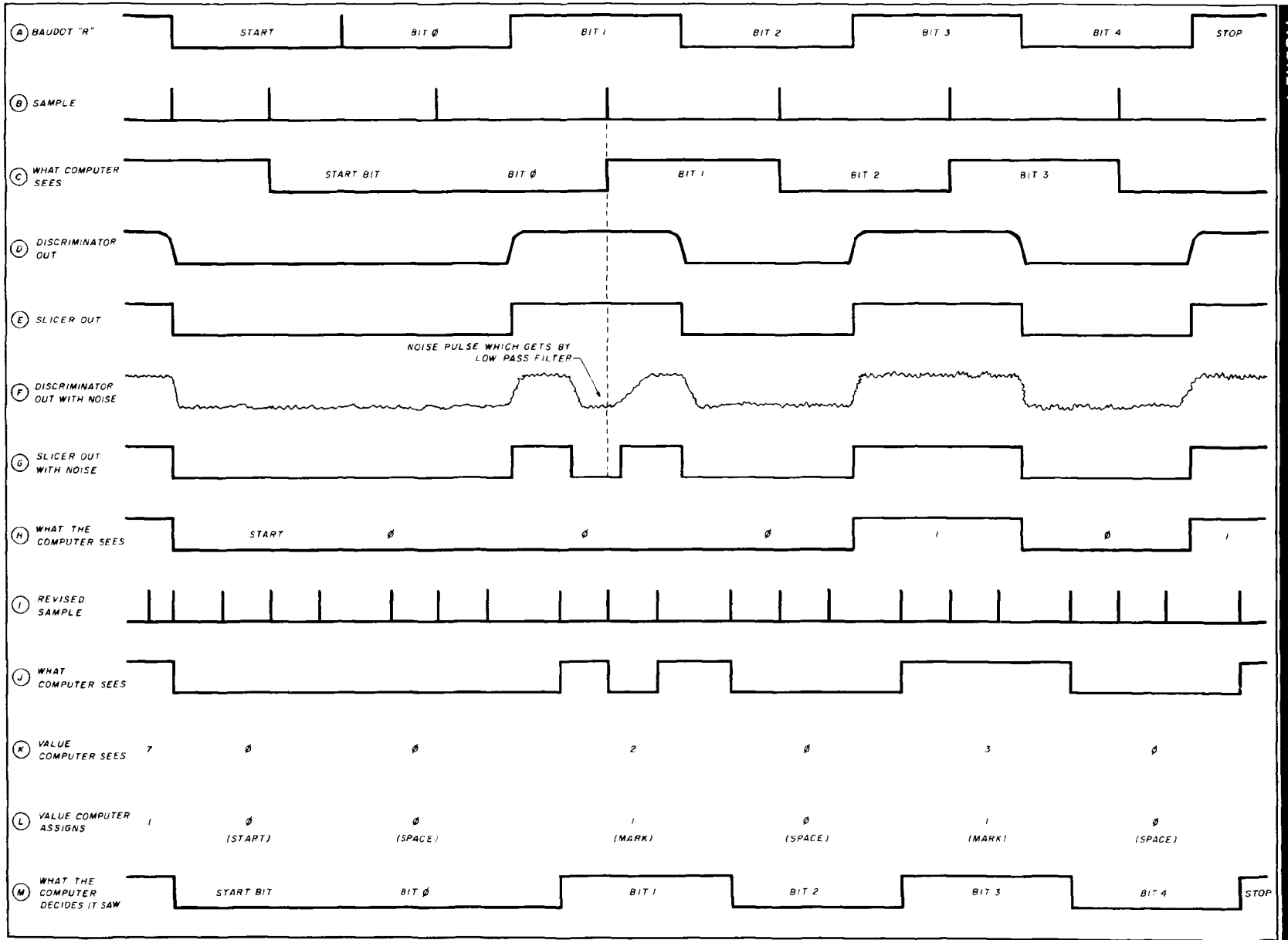
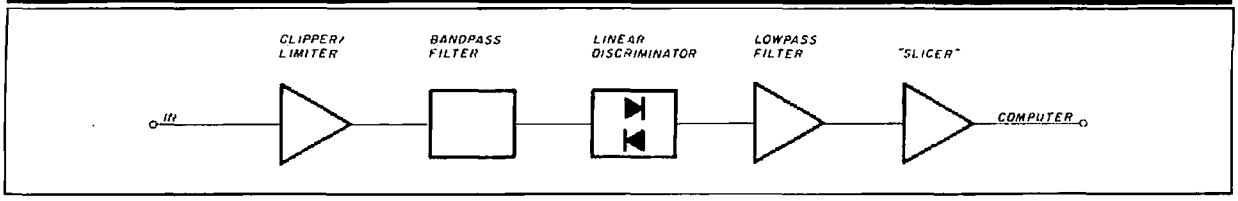


FIGURE 1

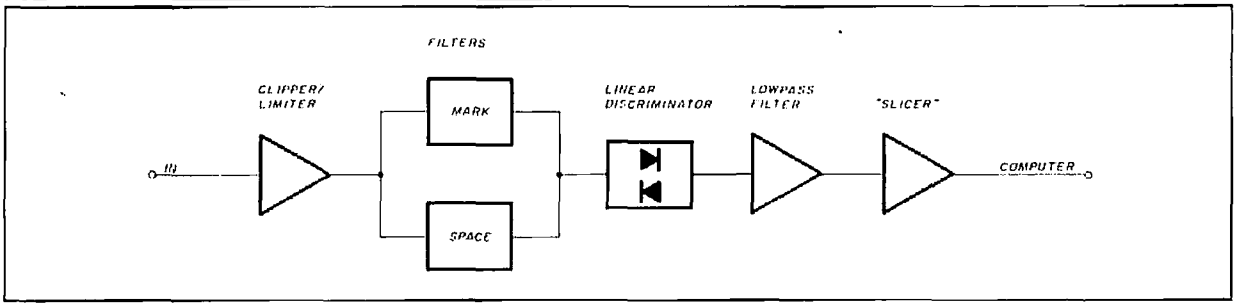
Waveform renditions of the letter "R" at various system locations.

FIGURE 2



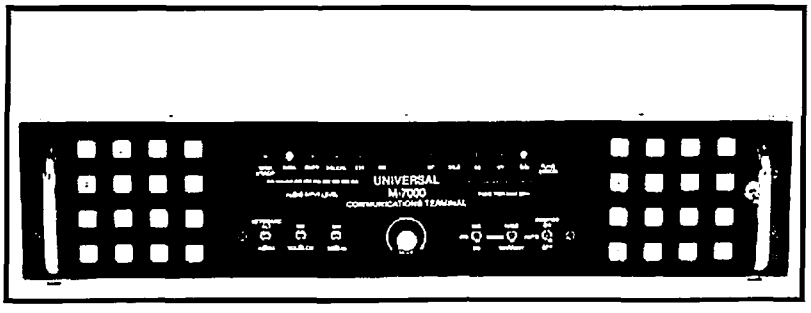
Typical RTTY demodulator.

FIGURE 3



Improved RTTY demodulator.

Monitor More With the New Universal M-7000!



If you are monitoring only *voice* shortwave stations, you are missing half the action! Thousands of shortwave stations transmit in non-voice modes such as Morse code, various forms of radioteletype (RTTY) and facsimile (FAX). The Universal M-7000 will permit you to easily intercept and decode these transmissions. Simple connections to your shortwave receiver and video monitor will enable you to monitor with the most sophisticated surveillance decoder available. No computer is required. See the world of shortwave excitement you have been missing. Requires 115 or 230 VAC. Six month limited warranty.

Partial List of Modes & Features

- ✦ Morse Code (CW)
- ✦ Regular Baudot RTTY
- ✦ Variable Speed Baudot
- ✦ Bit Inverted Baudot
- ✦ ASCII Low Speed
- ✦ ASCII High Speed
- ✦ ASCII Variable Speed
- ✦ Sitor Mode A (ARQ)
- ✦ Sitor Mode B (FEC)
- ✦ Autor
- ✦ ARQ 2&4 chan. (TDM)
- ✦ VFT Modes (FDM)
- ✦ Russian 3rd Shift Cyrillic
- ✦ Facsimile (FAX) AM
- ✦ Facsimile (FAX) FM
- ✦ Packet AX.25
- ✦ Literal Mode
- ✦ Databit Mode
- ✦ Diversity Reception
- ✦ Dual Metering
- ✦ Low Tone & High Tone
- ✦ Variable & Standard Shift
- ✦ Speed Readout
- ✦ 4 TTY Alphabets
- ✦ Ten Memories
- ✦ Automatic Tuning
- ✦ Video Squelch
- ✦ Audio Squelch
- ✦ Split Screen ARQ
- ✦ Self Diagnostics
- ✦ Screen Print
- ✦ Screen Saver
- ✦ Input Gain Control
- ✦ MSI, UOS, ATC
- ✦ User Programmable Sel Cals
- ✦ Serial & Parallel Printer Ports
- ✦ Remote Terminal Operation
- ✦ Direct Entry of Baud & Shift
- ✦ Auto-Start
- ✧ Option: Real Time Clock
- ✧ Option: Video Display of Facsimile (FAX)
- ✧ Option: Rack Mounting Brackets (For 19")

*** FULL CATALOG AVAILABLE ***

Universal offers a comprehensive shortwave catalog covering all types of shortwave monitoring equipment including receivers, antennas, RTTY and FAX equipment plus books and accessories. Send $1 (refundable) to receive your copy today.

Universal M-7000 Introductory Pricing:

- Standard M-7000 ..... $ 999.00
- With Real Time Clock Option $1059.00
- With Video FAX Option $1089.00
- With Clock & Video FAX Option .. $1129.00

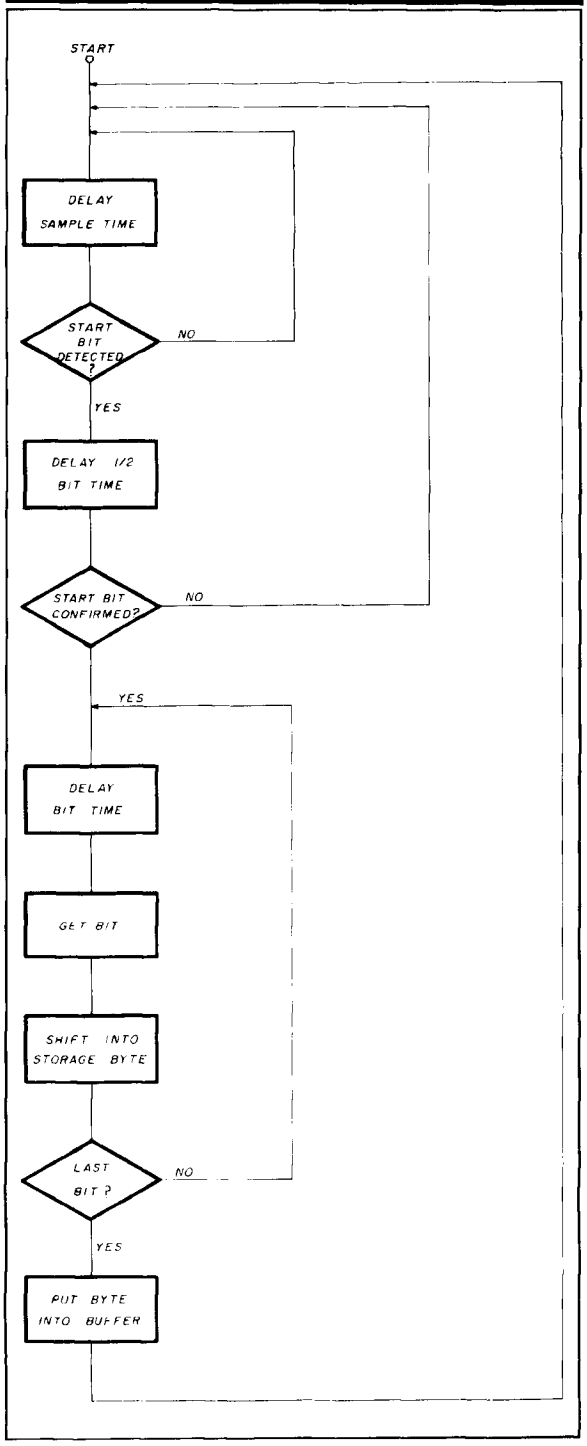
Shipping/Handling (USA) ..... $ 11.00

Universal...Serving Radio Enthusiasts Since 1942

Universal Radio
1280 Aida Dr. Dept. H
Reynoldsburg, OH 43068
Toll Free: 800 431-3939
In Ohio: 614 866-4267

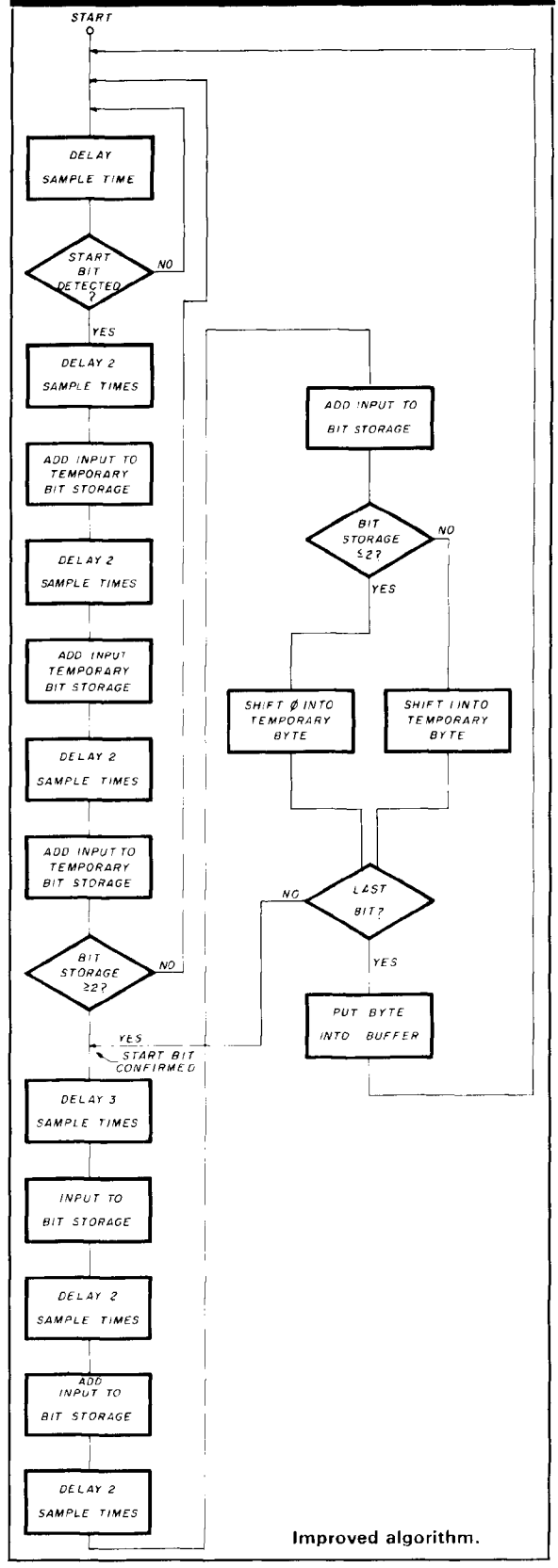
Figure 5 shows a flow chart for an improved algorithm. Initially, the computer takes seven samples per bit time, looking for a start pulse. When it detects a possible start bit, the computer waits two sample periods and takes another sample. (The delay prevents

FIGURE 4



Serial to parallel decoding algorithm.

FIGURE 5



Improved algorithm.

Make the most of your general coverage transceiver with *Monitoring Times*!

Every month *Monitoring Times* brings everything you need to make the most of your general coverage transceiver: the latest information on international broadcasting schedules, frequency listings, international DX reports, propagation charts, and tips on how to hear the rare stations. Monitoring Times also keeps you up to date on government, military, police and fire networks, as well as tips on monitoring everything from air-to-ground and ship-to-shore signals to radioteletype, facsimile and space communications.

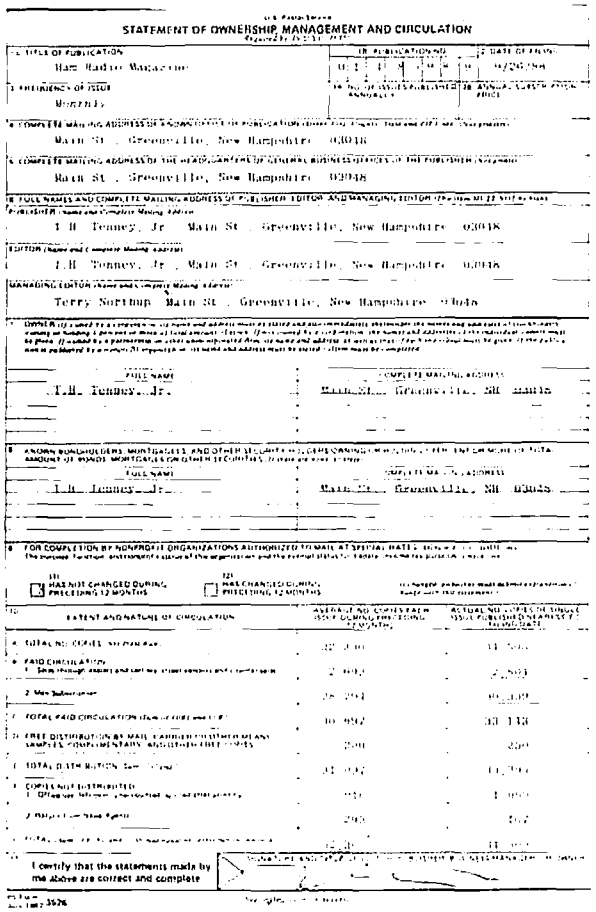
ORDER YOUR SUBSCRIPTION TODAY before another issue goes by. In the U.S., 1 year, $18; foreign and Canada, 1 year, $26. For a sample issue, send $2 (foreign, send 5 IRCs). For MC/VISA orders ($15 minimum), call 1-704-837-9200.

MONITORING TIMES

Your authoritative source, every month.

143

P.O. Box 98 A
Brasstown, N.C. 28902



STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION

1A. TITLE OF PUBLICATION: Ham Radio Magazine
1B. PUBLICATION NO.:
2. DATE OF FILING: 9/20/88
3. FREQUENCY OF ISSUE: Monthly
3A. NO. OF ISSUES PUBLISHED ANNUALLY:
3B. ANNUAL SUBSCRIPTION PRICE:
4. COMPLETE MAILING ADDRESS OF KNOWN OFFICE OF PUBLICATION: Main St., Greenville, New Hampshire 03048
5. COMPLETE MAILING ADDRESS OF THE HEADQUARTERS OR GENERAL BUSINESS OFFICES OF THE PUBLISHER: Main St., Greenville, New Hampshire 03048
6. FULL NAMES AND COMPLETE MAILING ADDRESS OF PUBLISHER, EDITOR, AND MANAGING EDITOR
PUBLISHER: T.H. Tenney, Jr., Main St., Greenville, New Hampshire 03048
EDITOR: T.H. Tenney, Jr., Main St., Greenville, New Hampshire 03048
MANAGING EDITOR: Terry Sorting, Main St., Greenville, New Hampshire 03048
7. OWNER

FULL NAME	COMPLETE MAILING ADDRESS
T.H. Tenney, Jr.	Main St., Greenville, NH 03048

8. KNOWN BONDHOLDERS, MORTGAGEES, AND OTHER SECURITY HOLDERS OWNING OR HOLDING 1 PERCENT OR MORE OF TOTAL AMOUNT OF BONDS, MORTGAGES OR OTHER SECURITIES

FULL NAME	COMPLETE MAILING ADDRESS
T.H. Tenney, Jr.	Main St., Greenville, NH 03048

9. FOR COMPLETION BY NONPROFIT ORGANIZATIONS AUTHORIZED TO MAIL AT SPECIAL RATES
(1) ☐ HAS NOT CHANGED DURING PRECEDING 12 MONTHS
(2) ☐ HAS CHANGED DURING PRECEDING 12 MONTHS

10. EXTENT AND NATURE OF CIRCULATION	AVERAGE NO. COPIES EACH ISSUE DURING PRECEDING 12 MONTHS	ACTUAL NO. COPIES OF SINGLE ISSUE PUBLISHED NEAREST TO FILING DATE
A. TOTAL NO. COPIES (Net Press Run)	37,000	33,500
B. PAID CIRCULATION 1. Sales through dealers and carriers, street vendors and counter sales	2,000	2,000
2. Mail Subscription	29,000	30,000
C. TOTAL PAID CIRCULATION (Sum of 10B1 and 10B2)	31,000	32,000
D. FREE DISTRIBUTION BY MAIL, CARRIER OR OTHER MEANS SAMPLES, COMPLIMENTARY, AND OTHER FREE COPIES	2,000	2,000
E. TOTAL DISTRIBUTION (Sum of C and D)	33,000	34,000
F. COPIES NOT DISTRIBUTED 1. Office use, left over, unaccounted, spoiled after printing	4,000	3,000
2. Return from News Agents	2,000	500
G. TOTAL (Sum of E, F1 and 2 - should equal net press run shown in A)	37,000	37,500

11. I certify that the statements made by me above are correct and complete

PS Form 3526

FIGURE 6

```
00100 ************************************
00115 *SMART DEMODULATION ALGORITHM        *
00125 *THIS INTERRUPT ROUTINE IS DESIGNED   *
00135 * TO BE CALLED 21 TIMES PER BIT TIME  *
00145 * IT ASSEMBLES THE RECEIVED CHARACTER *
00155 * AND STORES IT IN A BUFFER.  BETWEEN *
00165 *INTERRRUPTS, THE MAIN PROGRAM CAN GET *
00175 *THE CHARACTER AND DISPLAY IT.  NOTE   *
00185 * THAT A BAUDOT CHARACTER WILL BE      *
00195 *AS SENT, AND LEFT JUSTIFIED.  THE MAN *
00205 *PROGRAM MUST SHIFT THE CHARACTER INTO *
00206 *THE LSB'S AND TRANSLATE TO ASCII FOR  *
00207 *STORAGE.  (USE A TRANSLATION TABLE.)  *
00208 *COPYRIGHT 1987 BY JAMES A. SANFORD    *
00209 *    WB4GCS/NNNOHDF                   *
00210 ************************************
00220
00221 *WRITTEN IN 6809 ASSEMBLY LANGUAGE     *
00222 *INCOMING DATA RECEIVED AT $FF22, BIT 0*
00250
00300 SZIN    EQU    $100
00310 SZOUT   EQU    $100
00360 BITS    RMB    1        BITS/WORD INCLUDING START&STOP
00380 RXCTR   RMB    1        BITS RCVD
00381 RBTSTR  RMB    1        STORAGE FOR ACCUMULATED BITS
00386 RHITS   RMB    1        STORAGE FOR NUMBER OF SAMPLES
00390 TXCKS   RMB    1        TIMES PULSE CHECKED
00400 RXCKS   RMB    1        TIMES PULSE CHECKED
00450 XTMP    RMB    1        TEMP STORAGE FOR TX CHAR
00460 RTMP    RMB    1        TEMP STORAGE FOR RX CHAR
00470
00480 ONXTI   RMB    2        PTR FOR NEXT CHAR INTO OUT BUFFER
00490 ONXTO   RMB    2        PTR FOR NEXT CHAR FROM BUFFER TO SEND
00500 INXTI   RMB    2        PTR FOR NEXT RCVD CHAR TO BE STORED
00510 INXTO   RMB    2        PTR FOR NEXT RCVD CHAR TO BE SHOWN
00550
00551
02600         TITLE  INTERRUPT HANDLER
02610 FIRQ    PSHS   B
03215 RFIRQ   LDB    RXCTR    SEE IF RECEIVING ALREADY
03220         BEQ    RFNDST     NO, GO LOOK FOR START BIT
03225         DEC    RXCKS      YES
03230         BEQ    RUPDT
03235         LBRA   RIDON
03240
03245 RFNDST
03250         TSI    RXCKS    IF 0, LOOKING FOR FIRST HINT OF START BIT
03255         BEQ    FSTRTI
03260         DEC    RXCKS    ALREADY INTO IT; CHECK DELAY
03265         LBNE   RIDON    STILL WAITING
03270         LDB    $FF22    GET IT
03275         RORB
03280         BCS    RSTRT2
03285         INC    RBTSTR   UPDATE COUNTER
03290 RSTRT2  INC    RHITS    UPDATE NUMBER OF SAMPLES
03295         LDB    RHITS
03300         CMPB   #6
03305         BEQ    RSTRT3
03310         LDB    #2       NOT DONE, DELAY
03315         STB    RXCKS
03320         LBRA   RIDON
03325
03330 RSTRT3  LDB    RBTSTR
03335         CMPB   #4
03340         BLO    NOSTRT   NOT GOOD ENOUGH, START OVER
03345         LDB    #11      DELAY INTO NEXT FRAME
03350         STB    RXCKS
03355         LDB    BITS     SETUP TO GET DATA
03360         SUBB   #2       ADJUST, ALREADY HAVE STARI BIT
03365         STB    RXCTR
03370 RSTRT4  CLR    RHITS
03375         CLR    RBTSTR
03380         LBRA   RIDON
03385 NOSTRT  CLR    RXCKS
03390         BRA    RSTRT4
03395
03400 FSTRTI  LDB    $FF22
03405         RORB
03410         BCS    RIDON    NO START BIT,EXIT
03415         LDB    #5        START BIT, DELAY
03416         STB    RXCKS
03417         BRA    RIDON
03420
03435 RUPDT   LDB    $FF22    GET DATA BIT
03440         RORB            SHIFT INTO CARRY
03445         BCC    RUPD1    DATA BITS A 0
03450         INC    RBTSTR   DATA BITS A 1, COUNT IT
03455
03460 RUPD1   LDB    #2
```

Assembly language decoding algorithm for the 6809 microprocessor.

```
03465           STB     RXCKS   WAIT 2 SAMPLE TIMES, START AGAIN
03467           INC     RHITS
03470           LDB     RHITS
03475           CMPB    #6      6 SAMPLES YET?
03480           BNE     RIDON   NO, DONE FOR NOW
03485           LDB     RBTSTR  WE HAVE 6 SAMPLES, HOW MANY WERE 1?
03490 RUFD2     CMPB    #4      IF < 4, THE CMP WILL CAUSE A
03495 *                         BORROW, AND SET THE C BIT IN THE
03500 *                         CONDITION CODE REGISTER.  WE'LL CALL
03505 *                         THIS BIT A ZERO.
03510           EXG     B,CC    IF > 4 ONES, C WILL BE CLEAR, AND
03515 *                         WE'LL CALL THE BIT A 1
03520           EORB    #1      THE C BIT IS THE COMPLEMENT OF THE
03525 *                         REAL DATA, SO TOGGLE THAT BIT
03530           EXG     B,CC    NOW RESTORE REGISTERS
03535           LDB     RTMP    GET THE BITS WE'VE ALREADY GOT
03540           RORB            ROTATE NEW DATA BIT INTO TEMP
03545           STB     RTMP    STORAGE
03550           LDB     #11     SETUP TODELAY 3 SAMPLES FOR NEXT BIT
03555           STB     RXCKS
03560           CLR     RHITS
03565           CLR     RBTSTR  INITIALIZE COUNTERS
03566           DEC     RXCTR
03570           BNE     RIDON   WE'RE DONE.
03650 RSTOR     PSHS    X
03660           LDX     INXTI   GET PTR
03670           LDB     RTMP
03680           CMPB    #$FF    CK FOR ERRONEOUS END OF DATA FLAG
03690           BNE     RSTOR1    WHICH MAY HAVE BEEN CAUSED BY NOISE
03700           LDB     #$FE    IF SO, CHANGE TO $FE, WHICH WON'T AFFECT
03710 *                           BAUDOT, AND WILL HAVE MINIMAL EFFECT
03720 *                           ON ASCII TEXT. (NEVER INTENDED TO XFER
03730 *                           BINARY FILES IN ASCII)
03740 RSTOR1    STB     ,X+     TOBUFFER
03750           CMPX    #INBUF+SZIN
03760           BNE     RBFUP
03770           LDX     #INBUF
03780
03790 RBFUP     STX     INXTI   UPDATE BUF PTR
03800           CMPX    INXTO   THIS EXTRA ATTENTION TO BUFFER
03810           BNE     RBFUP1    MANAGEMENT IS NECESSARY TO
03820           LEAX    1,X       PREVENT NOISE INDUCED ERRATIC
03830           CMPX    #INBUF+SZIN
03840           BLO     RBFUP2    BEHAVIOR DURING DISK OPERATIONS
03850           LDX     #INBUF    OR BUFFER TRANSMISSION.
03860 RBFUP2    STX     INXTO
03870 RBFUP1    PULS    X
03880
03890 RIDON     PULS    B
03900           RTI
```

framing errors.) This pattern continues until three samples have been made. If two or three of the samples indicate that a start bit was present, a valid start is assumed. If not, the computer reverts to sampling each sample period in search of a start bit.

When a valid start bit is detected, the computer waits three sample periods and makes the first sample in the first bit. Three samples are taken per bit, with a delay of two periods between stored samples. After the samples for each bit have been collected, it is determined if the bit was a zero or a one. (I've chosen a simple majority of samples scheme; more sophisticated methods are possible.) This continues until all bits have been received and the character is stored in the buffer. Line I of **fig. 1** shows the revised sampling process; line J shows what the computer sees, given the noisy signal shown in lines F and G. Line K shows how the sample results are interpreted, and line L shows the results of the majority of samples. Line M shows the correctly reconstructed pulse train. Obviously, this process is not perfect. A long noise pulse which corrupts several samples within a bit can still corrupt the entire character.

This generic process can be enhanced in several ways. More samples per bit time yield greater noise immunity. The upper limit is determined by the amount of other processing your machine needs to do between samples. You may wish to sample five times per bit at *each* sample period instead of every other sample period.

Although I've demonstrated the concept using Baudot code, the data can be simple ASCII or any other serial format. As mentioned *earlier*, using this process in a packet or AMTOR system can improve throughput by reducing the number of error-related retransmissions.

implementation

How do you put this to use in your system? The timing involved is too fast and critical for interpreted languages like BASIC. I used assembly language for the 6809 microprocessor with 21 samples per bit. (See **fig. 6.**) A compiled language like C will probably work as well, depending on the speed of your machine and the efficiency of your compiler. While I don't have the test equipment to make quantitative comparisons, on-the-air tests show that the "smart" algorithm is a noticeable improvement over a more conventional scheme.

I'm interested in any results you get using this method, suggestions you may have for improving the technique, or other ways you've found to improve data copy.

NOTE: A complete working program for the Radio Shack® TRS80 color computer 3 is available from the author for $15.00. It features split screen, auto capture buffer (SELCALL), and several Baudot speeds as well as 300 baud ASCII.

Article G **HAM RADIO**

HAM RADIO SHIRTS and HATS GREAT Holiday Gift Ideas!

Here's a great way to say you're a HAM RADIO reader. Get a hat with your name and call and wear your HAM RADIO Magazine shirt!



Baseball Caps come in gold, blue, red and kelly green. Please give us the name and call sign you want lettered on the hat (maximum of 6 characters per line.)
UFBC (comes in gold, blue, red, kelly green) $5.95



HAM RADIO shirts come in two attractive styles. The TEE shirt is great for general everyday use. The HAM RADIO polo is for a more formal occasion. Each shirt is made of a 50/50 blend and comes in either blue or red. The new HAM RADIO logo is silk-screened in a vibrant yellow color on the front of each shirt.

Sizes Available: S, M, L, XL

HR-TEE B (blue) R (red).....$ 9.95
HR-PLO B (blue) R (red).....$19.95

Please enclose $3.50 to cover shipping and handling.

VISA

HAM RADIO BOOKSTORE
GREENVILLE, NH 03048 (603) 878-1441



(continued from page 59)

facilitating "Gateway" station operation — VHF to HF digipeating.

Version 1.2 of the controller software is greatly expanded and includes many of the features advanced packeteers are looking for. Significantly updated is the basic TNC controller. Also included is a Terminate and Stay Resident, TSR, driver and THS, a split screen full color terminal program. The TSR program allows you to run the TNC in the "background" while running other PC programs. TSR also has a user accesable programming interface should you want to customize the program. THS includes pop-up windows for menus and support functions, scroll buffer, ASCII file transfers, connect directory, message storage and printer support. A more complete description is beyond the scope of this review. Also included is Packet.Bat, which loads the AX.25 driver and then starts the terminal program.

Using the PCPA is fun, especially if you want to use your computer as more than just a TNC controller. I'm sure that as more people use the card, new and more powerful software will be written to run the PCPA. DRSI has done its homework and offers a very good way to get into packet. Price for the PCPA is $139.95; the HF modem is $79.95.

DRSI is also distributing AA4RE's Multi Connect Bulletin Board System. This package is fully compatible with "RLI/MBL" systems, but has the advantage of supporting multiple simultaneouos user connections on the same frequency. It does this without using any extra software, like Desqview or DoubleDOS. The AA4RE BBS is included with the DRSI PC*Packet Adapter at no cost.

For more information contact: DRSI, 2065 Range Road, Clearwater, Florida 34625.

N1ACH

WRITE FOR

FREE BOOK CATALOG

Ham Radio's Bookstore
Greenville, NH 03048



New Kantronics publications released

Kantronics, Inc./Kantronics Press has published several digital communication books and other books related to Amateur Radio. The latest title releases include: *RS-232 and Packet, Advanced Packet Operation, Packet Commands, The Packet Glossary of Terms, Quick Start Packet, Communications Tables, The Hamfest Book*, and *The Ham Club Book*.

The books retail in the United States for $2.95 each, plus $1.00 shipping and handling. To order, contact your Kantronics dealer, HAM RADIO's Bookstore, or the factory.

For more information contact, Kantronics, Inc., 1202 E. 23rd Street, Lawrence, Kansas 66046.

Circle #302 on Reader Service Card.

Heavy duty antenna rotator

The R9100 rotator is a heavy duty, state-of-the-art unit from the company that brought you the microprocessor controlled 230-series linear amplifier. The R9100 provides 10,000 in-pounds of torque, 23,000 in-pounds braking, and will support a 2,000 pound vertical load. The unit is 14.9 × 25 × 15.1 inches, fits inside Rohn 45 tower, and weighs 230 pounds. The control unit provides both analog and digital displays, manual control, and an RS-232 interface for external computer control. Software is provided (enter a prefix and the rotator will turn to the appropriate heading automatically). The unit is sold exclusively by EEB, Vienna, Virginia. The suggested list price is $3,975.

Contact EEB for additional information at 800-368-3270 or 703-938-3350.

Circle #303 on Reader Service Card.

New guide to technical specs available from Nemal

Nemal Electronics International has published a revised edition of its Cable and Connector Selection Guide. The new 40-page guide offers detailed technical specifications on more than 1000 military and commercial products. Product listings include triaxial cable and connectors, RF coaxial and semi-rigid cable and connectors, and crimping tools. To obtain a copy, please contact Nemal Electronics International, Inc., 12240 N.E. 14th Avenue, North Miami, Florida 33161 or call 800-522-2253 or FAX your request to 1-305-895-8178.

ICOM IC-448, 440-MHz mobile

ICOM is proud to introduce the new IC-448 25-watt 440-MHz mobile. The IC-448 features: a multi-colored LCD, frequency coverage 440-450 MHz, twenty memory channels, programmable scan, memory scan, and priority watch.

The IC-448 will be available in October 1988. Suggested retail price is to be announced.

Circle #304 on Reader Service Card.

1989 catalog of high-tech products

Radio Shack®, a division of Tandy Corporation has a new consumer products catalog featuring its 1989 product Included are: cellular telephones, video tape recorders, televisions, computers, software and peripherals, office equipment and more.

The computer products shown in the consumer catalog also appear in three other computer-specific catalogs. These catalogs include Tandy's entire line of software, peripherals and personal computers, including the industry's first IBM®Micro Channel™-compatible business computer and the $699 Tandy® 1000 HX computer.

Radio Shack catalogs are available, free of charge from your local Radio Shack outlet or by writing Radio Shack Circulation Department, 300 One Tandy Center, Fort Worth, Texas 76102.

Circle #305 on Reader Service Card.

Versatile CTCSS encoder-decoder

Communications Specialists introduces the TS-32P Programmable CTCSS Encoder-Decoder. It has all the features of the TS-32, but uses a new microcircuit for more tone versatility. The new IC-110 microcircuit in the TS-32P contains a 32-bit reprogrammable memory that allows specification of any 32-tone frequencies from 15.0 Hz to 255.0 Hz. The desired tone frequency can be called from the memory with a five-position DIP switch mounted on the TS-32P circuit board. Frequency accuracy is ± .01 Hz.

The TS-32P uses custom memory programming to provide multi-tone switching of up to six tones without requiring diode networks. The TS-32P allows easy access to any non-standard tone frequency. The 32-location tone memory can be changed with a handheld programmer available from Communications Specialists, or by returning it to the factory for re-programming at no charge.

The TS-32P measures 1.25″ wide × 2.0″ long × 0.40″ high and operates on 6 to 25Vdc. The retail price of the TS-32P is $57.95. A catalog is available on request.

(continued on page 104)

A HOMEBREW TUNING DIAL

By John Pivnichny, N2DCH, 3824 Pembrooke Lane, Vestal, New York 13850

Build a smooth, low cost, accurate dial for your next rig

Modern transceivers require precision tuning with zero backlash. This *analog* dial has 1-kHz markings and a 250-kHz tuning range. I used a commercial plastic circular disc protractor for the dial scale.[1] The dial can be constructed with home workshop tools. The information below can also be used to modify the dimensions, tuning ratio, tuning range, or tuning capacitor for your own homebrew equipment needs.

string drive

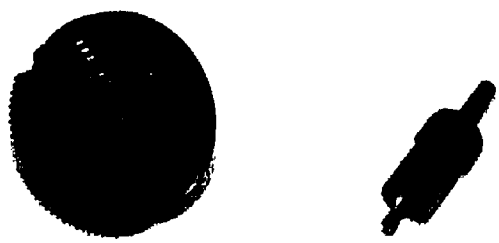
The dial's key feature is the use of dial cord and pulleys for the drive mechanism. Selecting the proper pulley diameter makes almost any tuning ratio possible. For example, I wanted to use 250 degrees of dial rotation for a 0 to 250 kHz tuning range and 25 to 30 kHz per turn of the main knob to give a good tuning rate. This is about a 14:1 ratio.

I also wanted to use 160 degrees rotation of the tuning capacitor for this 250-kHz range. The capacitor shaft rotates 1.6 times slower than the dial shaft. A larger pulley provides the right ratio.

Calculations show that you need a 1/16-inch shaft for the main tuning knob, a 2-inch pulley for the dial shaft, and a 3-1/4 inch pulley for the capacitor shaft.

I used a variable capacitor, enclosed in a shield can with an oscillator coil, salvaged from the rear of an ARC5 Command set transmitter. Its ball bearing construction allows the shaft to rotate with very low friction. Most variable capacitors will work, but try to find one of these. Check with the old-timers at your local club or Fair Radio Sales.[2]

FIGURE 1



Drill attachments for cutting pulleys.

pulley construction

You'll have to make the pulleys, but this isn't hard. The raw material is Plexiglas™ sheets 3/16 or 1/4 inch thick available from glass supply shops. Pulleys with a diameter of 2-3/8 inch or less can be cut with the an electric drill hole cutter. The drill attachment (**fig. 1**) found in most hardware stores has a series of removable blades. (Another style is also shown.) Cut larger diameters with a jigsaw, coping, or saber saw.

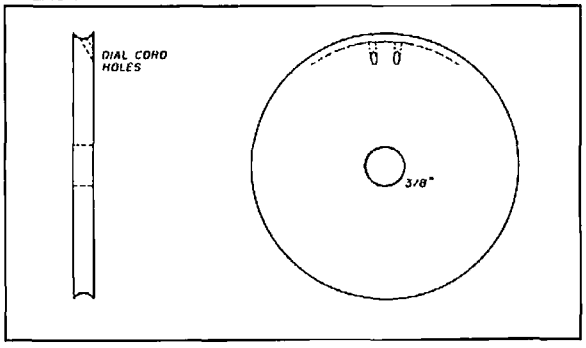
After cutting the disc, remove any imperfections and cut the groove in the outer surface. Enlarge the center hole to 3/8 inch diameter. Find a potentiometer with a locking shaft (**fig. 2**). It looks like an ordinary potentiometer, but the mounting bearing has four or six slots and a one-way locking nut with a tapered diameter that can be tightened to secure the bearing to the shaft. You will also need five ordinary potentiometers. The resistance value doesn't matter because only the bearing will be used.[3]

FIGURE 2



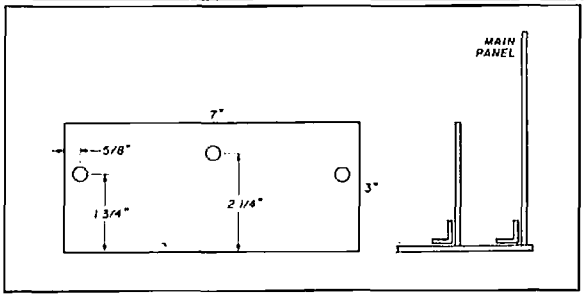
Potentiometer's source for bearings. Note one on right has a shaft-locking nut

FIGURE 3



Pulley details.

FIGURE 4



Mounting panel.

Gently extract the bearings from the potentiometers by removing a C-clip from the shaft and prying open the body. Tear away the top covers and discard the remains.

Purchase a 3-1/2 inch length of 1/4 inch steel shaft from the hardware store. You will need about 2 inches for the capacitor drive pulley and about 1-1/2 inches for the dial shaft pulley. Long shafts from the potentiometers can be salvaged and used. Mount a rough-cut pulley on the locking bearing, lock it onto the 1-1/2 inch shaft, and place it in the chuck of your electric drill. Clamp the drill body in a vise, turn it on with the locking button and start filing the outer edge.

When the pulley is perfectly round, use the edge of the file to cut the groove. Drill small holes as shown (**fig. 3**) for the dial cord. This simple operation makes an excellent drive pulley.

panel mounting

Bearings, salvaged from the potentiometers, are fixed in a section of sheet aluminum mounted 1-1/16 inches behind the front panel. See **fig. 4** for details. A 1 x 3 inch opening is cut in the main panel for the dial window. Two pieces of clear Plexiglas, 1/16 inch thick or less and 1-1/2 by 4 inches, are needed to cover the window opening and serve as a backup for the dial. Scribe a vertical line in the center of the front face on the rear Plexiglas piece. Fill the line with black ink to serve as a cursor. Use machine screws 4-40 x 3/4 inch to mount the Plexiglas parts to the front panel.

main drive shaft

A shaft 1/16 inch in diameter used with the main tuning knob drives the dial cord. Make this with brass rod, available at hobby shops. Cut 6-32 machine screw threads with a die as shown. Then thread on 1/4 inch spacers to fit the bearings and permit mounting the tuning knob. I used a 1-3/4 inch knob with two set screws.[4]

dial

Most of the circular protractors I have seen have two sets of numbers, one reading forward and one backward. I recommend you cut a circular disc of just the right diameter from Plexiglas to cover the inner set of numbers. Paint it an opaque color. I also filed a small notch for the 0 and 180 degree markings.

final assembly

The capacitor drive and dial pulleys are assembled as shown in **figures 5A** and **5B**. Complete the assembly by mounting three bearings in the mounting bracket and one in the main panel. This one must be aligned with the shaft in place; first tighten the front bearing, then the rear one. You may need to use emery cloth on the shafts to insure smooth operation. Finally, string the dial cord as shown in **fig. 6**.

additional notes

I used the capacitor mentioned earlier by mounting it 5/8 inch off the bottom panel on two brackets.

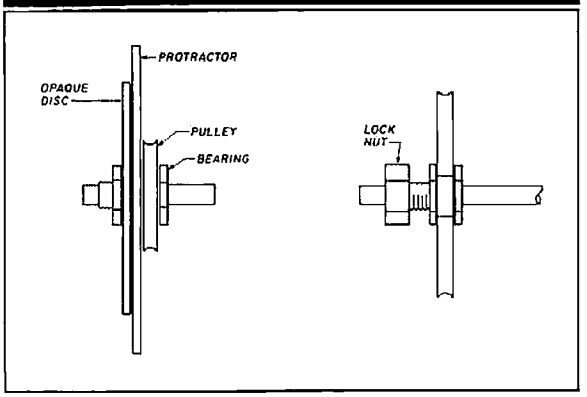
My favorite oscillator circuit is one that always works with any combination of L and C.[5] Use silver mica capacitors in the tank circuit.

You can do some calculations to determine how far off a linear frequency dial will be with a linear capacitance tuning capacitor (see Appendix). In my case I wanted to tune 11.5 to 11.75 MHz. I calibrate the two ends of the dial, adjust L at the low frequency end and C at the high frequency end. The error at the center

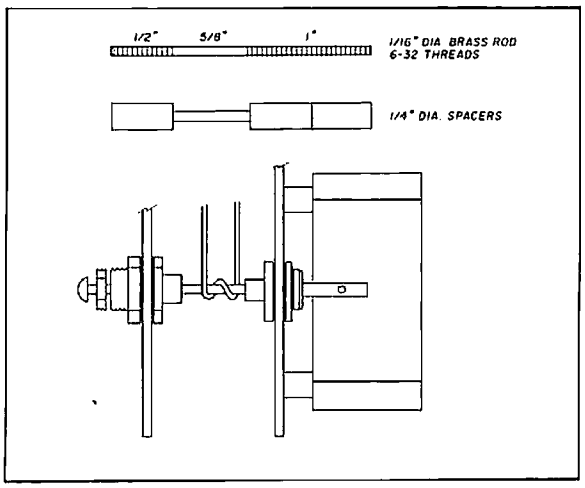
will be theoretically 2.0 kHz low. You can improve this by calibrating the ends 1 kHz high.

Because of the fairly large tuning capacitor I selected, I needed a very small inductor (about two turns on a 1/4 inch form). To allow for a more reasonable inductor, I modified the tank circuit to that shown in **fig. 8**. This reduces the effective capacitance by a factor of 4 and increases the allowable inductance by

FIGURE 5

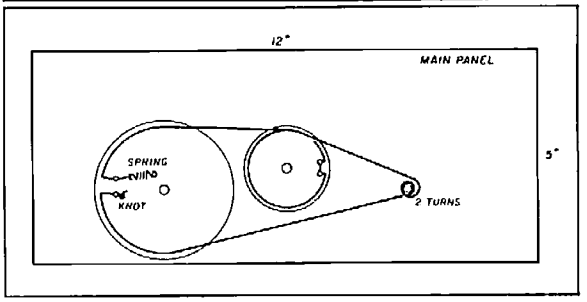


A. Pulley assembly.



B. Drive shaft.

FIGURE 6

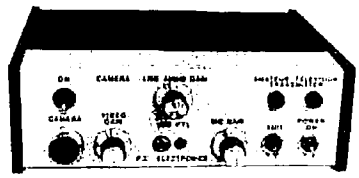


Dial string diagram.

AMATEUR TELEVISION

NOVICES: NOW YOU CAN TRANSMIT VIDEO WITH OUR NEW TX23-1

Did you know that you as well as all classes of licensed amateurs can easily transmit live action color and sound video just like broadcast TV with our TX23-1 transmitter. Use any home TV camera and/or VCR, computer, etc. by plugging the composite video and audio into the front 10 pin or rear phono jacks. Call or write now for our complete ATV catalog including downconverters, transceivers, linear amps, and antennas for the 70, 33, & 23cm bands.



Only $299

TX23-1 one watt ATV transmitter crystaled for 1289.25 MHz runs on 12-14 Vdc @ .5A. PTL T/R switching. 7x7x2.5". Transmitters sold only to licensed amateurs for legal purposes verified in the latest Callbook or with copy of license sent with order.

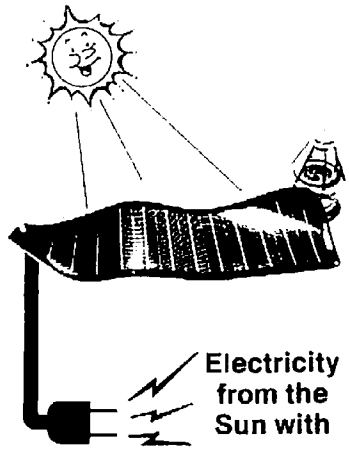
(818) 447-4565 m-f 8am-5:30pm pst.

P.C. ELECTRONICS
2522 Paxson Ln Arcadia CA 91006

Tom (W6ORG)
Maryann (WB6YSS)

151

LET THE SUN DO THE WORK



Electricity from the Sun with

SOLAREX Solar Systems

- Charge batteries on stored machinery
- Light your tent
- Run fans
- Run remote transmitters
- Light signs
- Pump water for your animals
- Power for your motor home
- Run your radio without batteries
- Light your home
- Yard lights
- Charge flashlight batteries
- Light your cabin
- Run electric fences
- Charge your boat battery
- Run appliances in your home
- Charge hand held radio batteries
- Fish shanty lights
- Charge your Camcorder battery pack

ALSO: *OUTSTANDING* PRICES ON IBM XT COMPATIBLE SYSTEMS!

SHIPPING INFORMATION: PLEASE INCLUDE 10% OF ORDER FOR SHIPPING AND HANDLING CHARGES (MINIMUM $2.50, MAXIMUM $10). CANADIAN ORDERS, ADD $7.50 IN US FUNDS. MICHIGAN RESIDENTS ADD 4% SALES TAX. FOR *FREE* FLYER, SEND 22¢ STAMP OR SASE.



HAL-TRONIX, INC. (313) 281-7773
12671 Dix-Toledo Hwy
P.O. Box 1101
Southgate, MI 48195

Hours
12:00 - 6:00 EST Mon-Sat

152

"HAL" HAROLD C. NOWLAND
W8ZXH

that same factor. Note, however, that the theoretical error also increases to 4.7 kHz at the center of the dial.

measured results

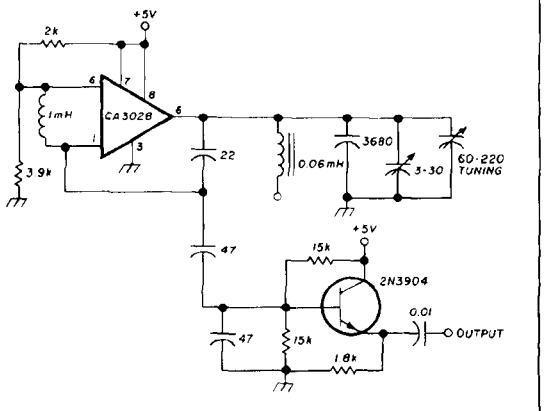
Table 1 lists actual frequency counter readings taken with the circuits in **figs. 7** and **8**. The +2 to −3 kHz errors agree with the calculated figure of 4.7 worst case.

Resettability is excellent. Returning the dial to 0 degrees puts the output right back at 11,500. One turn of the main tuning knob covers 28 kHz.

There is no backlash or slippage, and because of the high pulley ratio, no force is required to turn the knob. In these respects the dial is equivalent to an expensive zero backlash gear train drive like those used in modern transceivers.

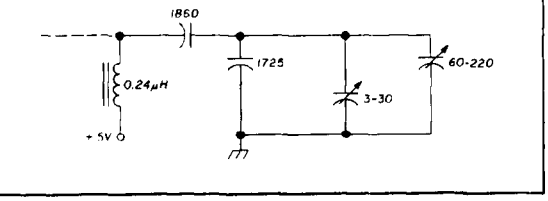
Give this homebrew dial a try. I'm sure you'll enjoy its economy and accuracy.

FIGURE 7



Oscillator circuit.

FIGURE 8



Modified tank circuit.

TABLE 1

Frequency counter readings taken with the oscillator and modified tank circuits.

dial setting (degrees)	frequency (kHz)	error (kHz)
0	11,500	0
50	11,549	−1
100	11,597	−3
150	11,647	−3
200	11,699	−1
250	11,752	+2

references

1. Available at most stationery supply stores in the drawing instrument section.
2. Fair Radio Sales, Lima, Ohio.
3. Other sources of bearings are phone jacks and rotary switches.
4. The knob shown in the photograph is Electronic Hardware Corporation model EH71-4D skirted round Regent Series.
5. *Linear Data Book*, National Semiconductor, June 1976, pages 10-132.

Appendix

Assume you are using a linear capacitance variable which goes from C_{max} to C_{min}. (These values are not necessarily the maximum or minimum values but the ones used for the actual degrees of rotation.)

The low frequency will be:

$$Flo = 1/2\pi \sqrt{L\ (C + Cmax)} \quad (1)$$

and the high frequency:

$$Fhi = 1/2\pi \sqrt{L\ (C + Cmin)} \quad (2)$$

These two equations (1) and (2) can be solved for the required fixed capacitance C.

$$(C + Cmax) \times Flo^2 = (C + Cmin) \times Fhi^2 \quad (3)$$

$$C = \frac{Cmax \times Flo^2 - Cmin \times Fhi^2}{Fhi^2 - Flo^2}$$

Then at the center of the dial, the variable capacitor will be at:

$$(Cmax - Cmin) / 2 + Cmin = (Cmax + Cmin) / 2 \quad (4)$$

and the frequency will be:

$$Fmid = 1/2\pi \sqrt{L[C + (Cmax + Cmin) / 2]} \quad (5)$$

In my case C_{max} = 220 pF, C_{min} = 60 pF, F_{lo} = 11.5 MHz, F_{hi} = 11.75 MHz.

$$C = \frac{220 \times 11.5^2 - 60 \times 11.75^2}{11.75^2 - 11.5^2} \quad (6)$$

$$C = 3580.43\ pF$$

From equation (1):

$$Flo = k/\sqrt{3580.43 + 220} \quad (7)$$

At Flo = 11.5, k = 708.9477 then:

$$Fhi = 708.9477 / \sqrt{3580.43 + 60} = 11.74999 \quad (8)$$

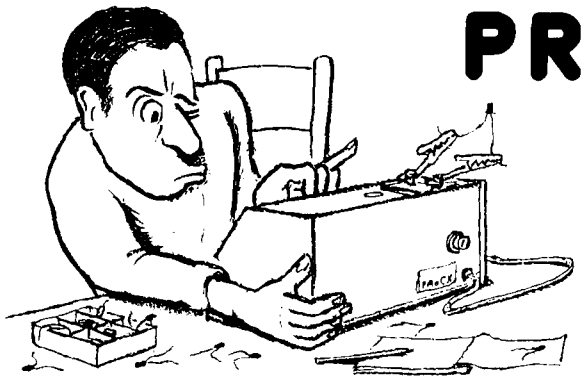
$$Fmid = 708.9477 / \sqrt{3580.43 + 140} = 11.62298$$

which for a correct dial should be 11.625 MHz, error = 2.0 kHz.

Article H **HAM RADIO**

OCTOBER WINNERS

A round of applause for Ronald Murdock, WB5FIX, our October sweeps winner and Joel Eschmann, K9MLD, author of October's most popular WEEKENDER – "Remote Tuner for 75-Meter Mobiles." Both will receive a handheld radio. To enter for December's drawing, send in the evaluation card bound into this issue, or submit a WEEKENDER project. You could be our next winner! *Ed.*



PRACTICALLY SPEAKING

Joe Carr, K4IPV

Overview of Operational Amplifiers: Part 2 — Inverting and Noninverting Follower Circuits

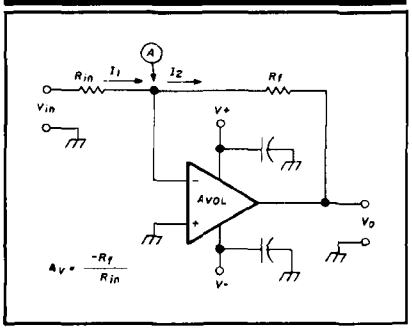
Last month I gave you the basics of the operational amplifier and other linear IC devices. I discussed the properties of the ideal op amp, and some common problems that represent departures from that ideal. This month I'll take a look at the standard circuit configurations and the derivation of transfer functions. Let's start with the inverting follower configuration.

Inverting follower circuits

Figure 1A shows the inverting follower circuit. It is characteristic of an inverting follower that the output signal is 180 degrees out of phase with the input signal (photo A). The transfer function is $A_v = V_o/V_{in}$.

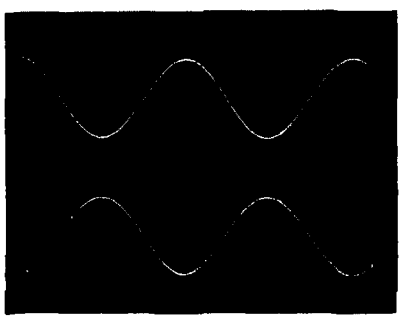
The noninverting input is grounded in the inverting follow circuit, so you must treat the inverting input as if it were also grounded. Ideal property number 6 (see last month) requires that the inverting input be treated as if it were also grounded, as at zero volts potential. This gives rise to a somewhat confusing concept — virtual ground. The inverting input isn't actually grounded, but since it's at zero potential because the other input is grounded, you can say that it is "virtually" grounded. The concept is simple; only the semantics are confusing.

FIGURE 1



Inverting follower circuit.

PHOTO A



Input (top) and output (bottom) waveforms of a gain of −1 inverting follower.

Let's consider the currents appearing in node "A" of fig. 1. You know from ideal property number 3 (Z_{in} is infinite) that I3, the input bias current, is zero. You also know from Kirchoff's Current Law (KCL) that all currents into and out of a junction algebraically sum to zero. Thus,

$$I1 = -I2 \quad (1)$$

You also know from Ohm's law that

$$I1 = V_{in}/R_f \quad (2)$$

and,

$$I2 = V_o/R_{in} \quad (3)$$

Thus, when you substitute these two equations into KCL:

$$(V_{in}/R_{in}) = -(V_o/R_f) \quad (4)$$

You know that a voltage amplifier's transfer function is:

$$A_v = V_o/V_{in} \quad (5)$$

Solving eqn. 4 for the transfer function (eqn. 5) yields:

$$V_o/V_{in} = -R_f/R_{in} \quad (6)$$

Thus, the voltage gain A_v of the inverting follower is given by the ratio of two resistors:

$$A_v = -R_f/R_{in} \quad (7)$$

You can design the inverting amplifier by manipulating the values of these two resistors (see fig. 1). That's the exciting part of op amp theory, and what makes the device so simple to apply.

There's a constraint on the minimum allowable value of R_{in}. Point A is virtually grounded, so the input impedance of this circuit is the resistance of R_{in}. One rule of thumb of voltage amplifier design says the input impedance of a stage must be five times (some people, myself included, prefer ten times) the source impedance of the signal source.

Example:

Design a gain of 100 inverting amplifier that has an input impedance of 10k or more.

Solution:

Since the input impedance must be 10k, R_{in} must be 10k or more. Set it

at 10k. Solving the gain equation for R_f yields:

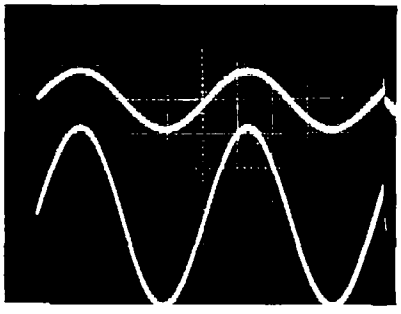
$R_f = A_v \times R_{in}$

$R_f = (100) \times (10{,}000\ ohms)$

$R_f = 1{,}000{,}000\ ohms$

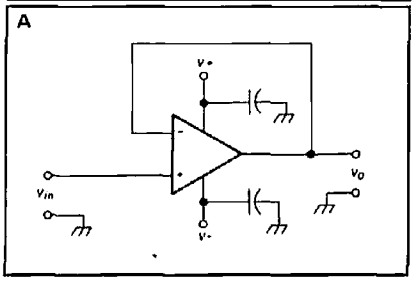
So, a 10k input resistor and a 1 meg feedback resistor yield a gain of 100. Since this is an inverting follower, the gain is actually −100. (The "−" sign indicates the 180-degree phase reversal between input and output normal to inverting amplifiers.)

PHOTO B



Input (top) and output (bottom) waveforms of gain of +2 noninverting follower.

FIGURE 2



Unity gain noninverting follower.

Noninverting followers

The noninverting follower applies a signal to the noninverting input. The output signal is in phase with the input signal (zero degree) phase shift (**photo B**). There are two basic configurations for the noninverting follower:

- Unity gain noninverting follower
- Noninverting follower with gain.

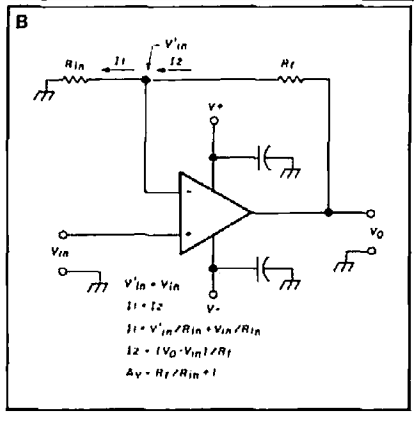
Figure 2A shows the unity gain noninverting follower. The output terminal is connected to the inverting input, producing 100 percent feedback. The output voltage is equal to the input voltage. So of what use is a unity gain (i.e., gain of 1) voltage amplifier? There are three principal uses: buffering, impedance transformation, and power amplification. Buffering means using an amplifier to isolate a circuit from its load. Some oscillators and astable multivibrators change frequency if the load impedance changes, so a unity gain noninverting follower helps "buffer" the circuit. Also, some transducers with high source resistances load badly if not buffered by an extremely high input impedance amplifier; the crystal microphone is one example.

Impedance transformation occurs because the input impedance is very high, while the output impedance is very low. You can use this circuit when acquiring a signal from biological electrodes or chemical transducers, etc., where the source impedance is extremely high. A pH electrode, for example, has source impedances ranging from 10 to 100 megs.

The voltage amplification is unity. This is illustrated by the fact that the voltage remains constant ($V_o = V_{in}$). Consider also that the impedances are unequal. Obviously, since power is defined by $P = V^2/R$, reducing R while keeping V constant results in higher power (P).

The noninverting follower with gain circuit in **fig. 2B** retains the properties of the unity gain circuit, but produces voltage gain as well. Keep in mind that the inverting input (point A) is at V_{in}. Analysis similar to the previously used

FIGURE 2



Noninverting follower with gain.

2x4Z BASE REPEATER ANTENNA

THE HIGHEST GAIN DUAL BAND BASE/REPEATER ANTENNA

HIGH POWER 200 WATTS

CENTER FREQUENCY
146.500 MHz
446.500 MHz

GAIN:
VHF - 8.2dB
UHF - 11.5dB
VSWR - 1.-1.2 or less

CONNECTOR:
N TYPE FEMALE

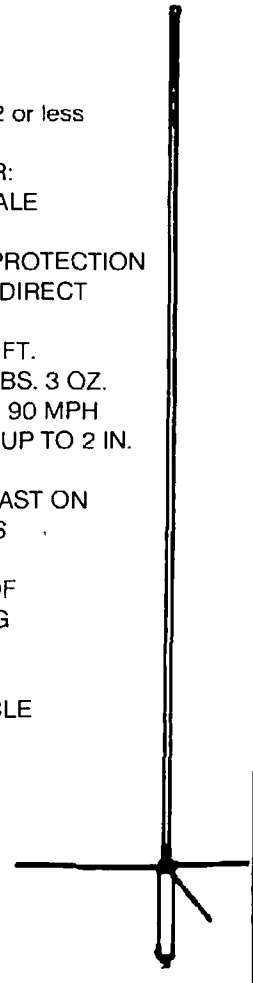
LIGHTNING PROTECTION
GROUNDED DIRECT

LENGTH: 16 FT.
WEIGHT: 5 LBS. 3 OZ.
WIND LOAD: 90 MPH
MOUNTING: UP TO 2 IN. MAST
CAN SIMULCAST ON BOTH BANDS

WATERPROOF CONNECTING JOINTS

UPS SHIPPABLE

154



AMATEUR SPECIAL

NCG

1275 NORTH GROVE ST.
ANAHEIM, CALIF. 92806
(714) 630-4541
CABLE: NATCOLGLZ
FAX (714) 630-7024

method produces a voltage gain of:

$$A_V = (R_f/R_{in}) + 1 \quad (8)$$

The noninverting follower circuits are used wherever extremely high input impedance is needed, or where no phase reversal can be tolerated. In communications circuits the noninverting gain follower is often used for audio microphone preamplifiers.

Operation from a single power supply

Operational amplifiers are normally operated from a bipolar DC power supply. Such a power supply has V+ and V− voltages that are each referenced to common. This system essentially requires two independent DC supplies. In some cases, however, either ultimate use or other design constraints lead to the necessity of a single (monopolar) DC power supply. An example is +13.8 mobile circuits. In this section I'll discuss simple methods for operating the amplifier from a single DC power supply.

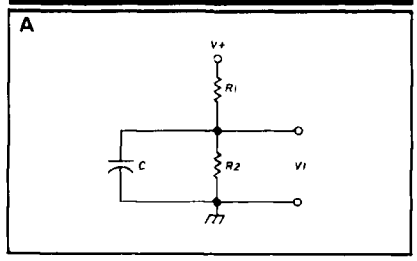
Some schemes exist for creating a split power supply from a monopolar one in order to mimic bipolar power supply operation. One scheme connects two zener diodes in series across the single supply, along with the necessary current-limiting resistors. The junction between the two zener diodes becomes the signal common. A severe limitation of this method is that the DC supply common can't be chassis referenced.

Another scheme is to use the regular monopolar DC power supply for V+, and a DC-to-DC converter circuit for V−. Such a circuit is little more than an AC or square wave oscillator in the 20 to 500-kHz range, with its output signal rectified and filtered to produce the V− voltage.

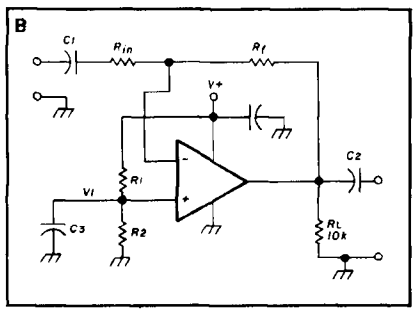
Figure 3A shows the method for biasing the operational amplifier inputs to permit single supply operation. This technique is based on the simple resistor voltage divider circuit in fig. **3A**. The output voltage (V1) is given by the standard voltage divider equation:

$$V1 = \frac{R2 \times (V+)}{R1 + R2} \quad (9)$$

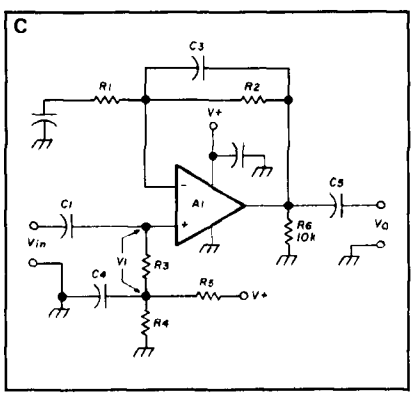
FIGURE 3



Resistor voltage divider.



Inverting follower operated from single supply.



Noninverting follower operated from single supply.

In most cases, the value of V1 will be one-half V+, so the operational amplifier has a quiescent output point that is midway between extremes. This bias level is achieved by making R1 = R2. The value of R1 and R2 is usually selected so that it falls between 1k and 100k. The capacitor shunting resistor R2 is used to decouple AC variations on the power supply line. The capacitance value is selected for a reactance value of one-tenth R2 (i.e., R2/10) at the lowest frequency of operation. For example, suppose R2 = 10k, and the lowest frequency of operation is 10 Hz. If R2 is 10k, then the capacitive reactance of the shunt capacitor should be: R2/10 = (10k)/10 = 1k. Solving the usual capacitive reactance equation for C gives you:

$$C_{\mu F} = \frac{1{,}000{,}000}{2\,\pi\,F\,X_c} \quad (10)$$

$$C_{\mu F} = \frac{1{,}000{,}000}{(2)(3.14)(10\ Hz)(1000\ ohms)}$$

$$C_{\mu F} = \frac{1{,}000{,}000}{62{,}800}$$

$$C_{\mu F} = 15.9\,\mu F$$

The value 15.9 μF is non-standard, so you'd select a 16, 20, or 22 μF standard unit.

Figure 3B shows the method for biasing an operational amplifier in the inverting follower configuration. In the bipolar supply version of this circuit the noninverting input is grounded (i.e., set to zero volts). But in single supply operation, you apply bias voltage V1 to the noninverting input. This voltage (V1) also appears on the inverting input, making DC blocking capacitor C1 necessary. The output terminal is biased according to the value of V1, and may also require a DC blocking capacitor (shown in fig. **3C**) if such a voltage adversely affects the following stage.

Select the value of capacitor C1 to have a low impedance at the lowest frequency of operation, using a protocol similar to that discussed for the voltage divider shunt capacitor. A general rule of thumb is to regard $R_{in}C1$ as a high-pass filter with a cutoff frequency, F_c, equal to $1/(6.28\ R_{in}C1)$. The object is to choose a value of C1, given a value for R_{in}, that results in a value of F_c lower than the lowest operating frequency.

The circuit configuration for noninverting follower circuits is shown in fig. **3C**. This circuit is the same as for inverting followers, except for resistor R3. The purpose of R3 is to maintain a high input impedance to signals applied to the noninverting input. The minimum value of R3 is at least ten times the output resistance of the driving stage. In practical cases, however, the source impedance is usually low enough that it's possible to set R3 to

100 or 1000 times the source impedance. Typical values range from 10k to 1 meg, with 100k predominating.

Select the value of C1 so that the cutoff frequency of the filter formed by C1R3 is lower than the lowest operating frequency. The same equation applies here as before. Use capacitor C4 and resistor R4 when the (V+)/2 bias on the output terminal will adversely affect a following stage or instrument. Again, the "lowest frequency of operation" rule is invoked when setting the value of C1, with the resistance being the input resistance of the following stage.

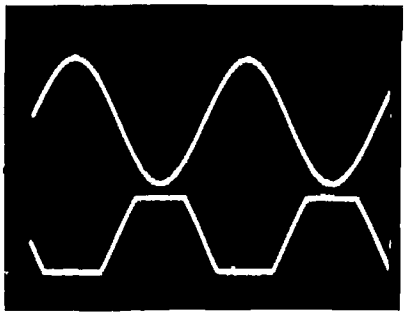
Some common problems

I find it almost impossible to wire up a circuit without making at least one mistake. Check your wiring before applying power to the circuit. Fortunately, most op amps will survive a whole host of errors — *except* reversed DC power supply polarity!

Before applying power you'll need to check a few things. Don't send a signal until after power is applied. Ground the input to simulate a signal of zero volts. Next, turn on the power and use a DC voltmeter to check the V− and V+ power supplies. Make sure these potentials are proper. Now check the output terminal. It should be 0 Vdc if you use bipolar supplies, or at the potential set by the voltage divider if you do otherwise (1/2−(V+) is common). If all's well, turn on the signal and check the circuit operation. If not, then turn off the power and look for the problem — you've probably miswired something. (An op amp from a "cheapie" source may well be defective.)

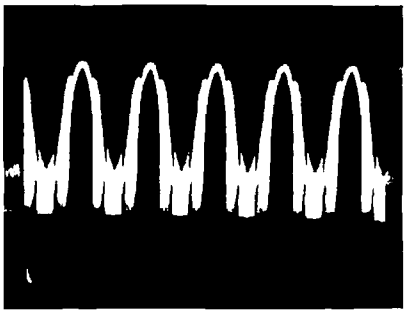
Photo C shows the result when the amplifier inputs are overdriven for the circuit conditions. Three factors can lead to the clipping shown in the output signal (lower trace). The first is excessive input signal. (This situation can also be dangerous to the op amp's health.) The second is a value that's too low for the DC power supplies (e.g., ±6 Vdc when ±10 volt output signals might be expected). The third factor is a gain that's too high for the

PHOTO C



Input (top) and output (bottom) waveforms of an overdriven amplifier showing "clipping."

PHOTO D



Ooops! Forgot the decoupling capacitors!

power supply value (i.e., when the V− and V+ supplies are maximum).

Photo D shows *oscillation* superimposed on a sine wave output signal. I took this photo from an oscilloscope connected to the output of a 741 amplifier in which the decoupling capacitors on the V− and V+ power supplies were missing. The solution is to place at least some decoupling at each op amp terminal as close as possible to the body of the device. Note that 741 devices are called "unconditionally stable" in some texts, so some people believe that they won't oscillate.

Conclusion

Applying operational amplifiers is easy. The one simple rule to remember is that the output/input transfer function is governed by the feedback network. For simple voltage amplifiers you need only remember that the ratio of the resistors is the determining factor. For AC amplifiers you'll also need to crank in the bypass capacitor values.

This article is based on my new book: *IC User's Casebook* (Sams No. 22488), available from the *HAM RADIO* Bookstore for $12.95, plus $3.50 shipping and handling. I can be reached at POB 1099, Falls Church, Virginia 22041, and would like to have your comments and suggestions for this column.

Article I **HAM RADIO**

K COMM., INC.
THE HAM STORE

Stocking all major lines. San Antonio's Ham Store. Great Prices—Great Service. Factory authorized sales and service. Hours: M-F 10-6, SAT 9-3

KENWOOD
YAESU
ICOM

5707A Mobud
San Antonio, TX 78238
800-344-3144
Orders Only

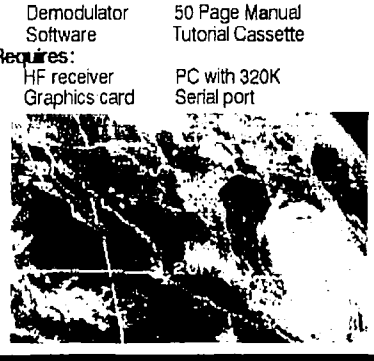
✓ 159

VISA MasterCard AMERICAN EXPRESS

PC HF FACSIMILE $79.95

A complete facsimile reception system for your IBM PC or compatible. Receive grayscale images in up to 16 shades or psuedo color depending upon your graphics card and printer.

Includes:
Demodulator Software — 50 Page Manual Tutorial Cassette
Requires:
HF receiver — PC with 320K
Graphics card — Serial port



Software Systems Consulting
1303 S. Ola Vista
San Clemente, CA 92672
(714) 498-5784

✓ 160

THE WEEKENDER



Get the most from your NiCds.

One way to maximize the useful life of your NiCds is to use them; they thrive on it! Part of this use should include full discharge and full charge cycles.

Many devices using NiCds come with a charger. Proper charging is usually easy to accomplish; it's simply a matter of charging them for a fixed period of time — often 16-20 hours. Proper discharge is not quite as easy to achieve.

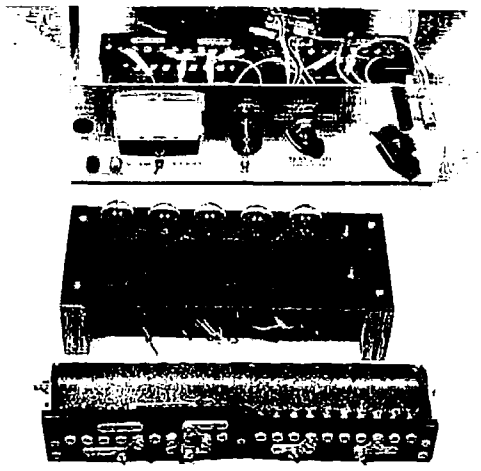
My first experience with NiCds was in 1960. The military used NiCd wet cells to power selected equipment. These NiCd power supplies were stored fully discharged and shorted. They were removed from storage periodically, checked for proper electrolyte level, and charged. Then they were discharged at a specific load for a specific time to test their capacity. Individual cell voltages were checked during the discharge cycle, and any cells which discharged prematurely were removed and replaced. The battery was again charged and given the timed discharge test to be sure that it met the capacity requirements. A NiCd battery is only as good as its weakest cell. I have some of those early NiCd cells. They're now about 30 years old, but still usable!

The first commercially available NiCds I purchased in the mid-sixties were C and D cells. I periodically ran discharge capacity tests, almost from the time I bought them. I dated and numbered each cell so that I could track its performance. Some of those cells lasted over 10 years. I've found that neither age nor number of cycles is necessarily an indicator of when a NiCd cell needs to be replaced.

For years I discharged NiCds with almost anything

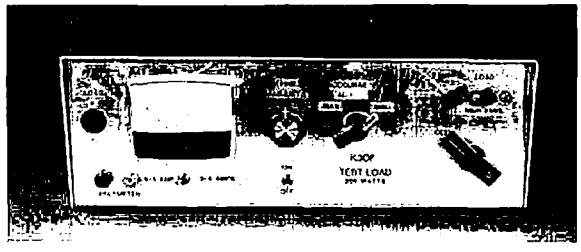
By W. C. Cloninger, Jr., K3OF, 4409 Buckthorn Court, Rockville, Maryland 20853

PHOTO A



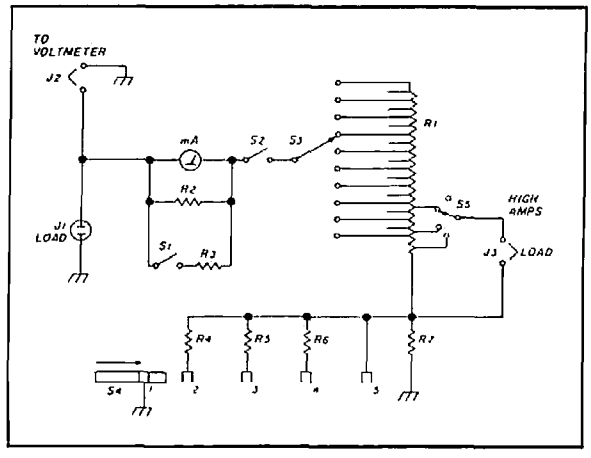
Multi-purpose test load is just a special purpose resistance substitution box.

PHOTO B



The multi-tapped resistor is the heart of the test load. Note the heavy-duty switch at the upper right for high amps.

FIGURE 1



Simple circuit for old-fashioned resistance-substitution box.

that would place a suitable load on them. I used flashlight bulbs, automotive accessories, high-wattage resistors, and 12-volt automotive bulbs. I also used an assortment of clip leads, ammeters, voltmeters, and battery holders. It was a mess, but it worked! There are still times when I use a gang of automotive bulbs (**photo A**).

I had known for years that it would be nice to have a clean, functional test load. I spotted a multi-tapped 200-watt 6.5-ohm resistor in a catalog.[1] A year or so later I ordered two of the resistors. I looked at them for another year. Then, one weekend I finally constructed my test load (**photo B**).

The circuit shown in **fig. 1** is simple; it's basically an old-fashioned resistance substitution box. But remember, all power from the discharge of the NiCd battery is dissipated in heat, so the resistors must be capable of handling the required power level. The power dissipation is calculated with either $P = IE$ or $P = I^2R$. A 13.8-ohm load across 13.8 volts

$$(I = \frac{E}{R},\ I = \frac{13.8}{13.8} = 1\ A)$$

equals 13.8 watts ($P = 1 \times 13.8 = 13.8$ watts). Because five resistors (R1, R4, R5, R6, and R7) share varied amounts of the 13.8 watts, no resistor needs to be rated over 10 watts. Switch S4 is a shorting type; I used it because that's what I had in my junkbox. If you use a non-shorting switch, calculate the values and maximum load on any single resistor and use a higher wattage resistor where required. **Table 1** gives the approximate resistance ranges of switch S4, when used with switch S3 for fine adjustment.

TABLE 1

Approximate resistance ranges of switch S4 when used with switch S3 for fine adjustment.

Range 1	1.1— 7.0 ohms
2	9.8—15.6 ohms
3	16.6—22.4 ohms
4	24.1—29.8 ohms
5	31.2—37.0 ohms

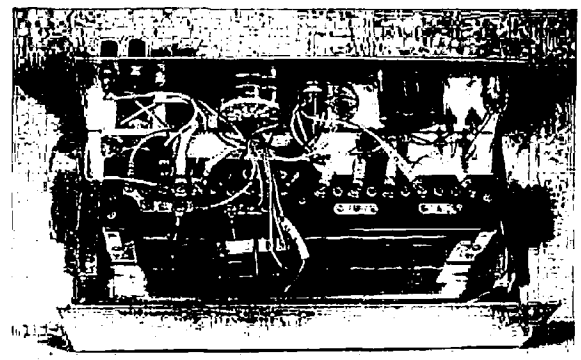
Construction

There's nothing special about the construction (**photo C**). Just about everything I used came from my junkbox. R1 is the only component purchased specifically for this project. Even the wires with the terminals were "cut-offs" from disassembled equipment. Switches S3 and S4 were what I had available. The meter is a 0-1 mA movement with shunts for 0-1 and 0-2 A. The shunts are lengths of resistance wire removed from some old wire-wound resistors.

Start by connecting one end of the resistor wire to the meter. Use a clip lead on the other terminal of the meter, and slide the other end of the clip lead along the resistance wire until you get the proper reading. (Place another ammeter in series for reference.) Solder a wire to the resistance wire at this point, and connect the wire to the meter. I added switch S1 and another shunt resistor to give the meter two ranges. The tip jacks for an external voltmeter were added as a convenience as was switch S2, which allows the load to be turned off or on without disturbing the load settings.

I also needed a high amp load capability to make power supply tests, so I added a second load circuit consisting of switch S5 and jack J3. The high amp section will handle loads of about 5 to 15 amps on a 13.8-volt power supply. Fifteen amps at 13.8 volts is pushing the rating of R1 and is used only for short times.

PHOTO C



Foreground: Load resistor R1 before installation. Center: 10-A continuous-duty test load is guaranteed to brighten up your shack.

PARTS LIST

R1	6.5 ohm 200 watt multi-tappad resistor*
R4	100 ohm 10 watt
R5	50 ohm 10 watt
R6	20 ohm 10 watt
R7	30 ohm 10 watt
S3	10 pole rotary switch
S4	5 pole shorting rotary switch
S5	4 pole high amp ceramic switch
Meter	0-1 mA, or to suit
R2,R3	shunt resistors to suit meter
J1,J2,J3	Jacks to suit needs

*H & R Corporation, 401 E. Erie Avenue, Philadelphia, Pennsylvania 19134

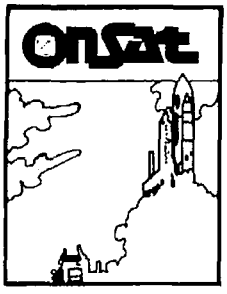
Part number TM23K513, $5.50 in December 1986 catalog.

Using the test load

The capacity of NiCd cells is usually stated for the 1-hour discharge rate. That is, a 450-mAh (milliamp hour) AA cell will support a 450-mA load for one hour if it's fully charged and has 100 percent capacity. C

OnSat

"America's Weekly Guide to Satellite TV"



The best in satellite programming! Featuring: ★ Over 120 Channels listed ★ Weekly, Updated Listings ★ Magazine Format ★ Complete Alphabetical Movie Listings ★ Sports Specials ★ Prime Time Grids ★ Specials ★Programming Updates!

- **Only $45.00 per year (52 weekly issues)**
- **2 Years $79.00 (104 weekly issues)**
- **$1.00 for sample copy**

*NC Residents must add 5% Sales Tax

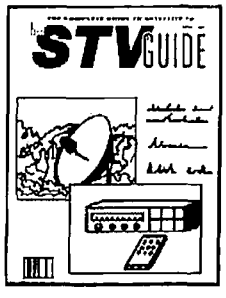
Subscribe Today!

call toll free 1-800-234-0021
Visa℠ and MasterCard® accepted

OnSat PO Box 2347 Shelby, NC 28151-2347

STV GUIDE

The new **STV Guide** contains valuable information on zoning regulations, scrambling, plus technical tips for installing or updating a satellite system—and now a precise monthly guide to satellite TV with the latest program listings for over **90 channels**!



All this in each complete issue of **STV Guide**!

- **Only $48.00 per year (12 monthly issues)**
- **$2.00 for a sample copy**

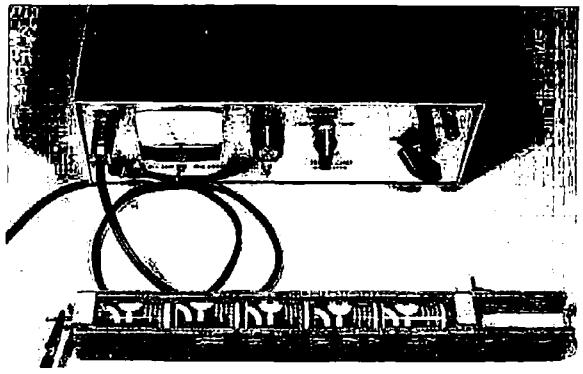
*NC Residents must add 5% sales tax

Subscribe Today!

Call toll free 1-800-234-0021
Visa℠ and MasterCard® accepted

STV Guide PO Box 2384 Shelby, NC 28151-2384

PHOTO D



Discharge capacity test using adjustable battery holder.

and D cells are typically 1200 mAh (1.2 Ah). For capacity tests, I use the 1C rate (one times capacity); i.e., 450 mA for AA cells.

The first step is to discharge all cells. I use a homemade battery holder (**photo D**) for single cells. It's easy to check each cell voltage individually with a voltmeter during discharge. One of the advantages of a NiCd cell is a relatively flat discharge curve. Notice, I said "relatively" flat. Voltage under 1C load will be about 1.2 volts for a long time. As it nears discharge, it will drop to 1.1 volts and — a very short time later — to 1.0 volt. The change in voltage at near discharge can take place in a matter of a few minutes, so watch the cells carefully. This isn't a "set it and leave it" test procedure. At 1.0 volt you can consider the cell discharged and pull it. However, don't let the cell drop below 1.0 volt, or it might reverse polarity and not recover when recharged. If you're discharging a fixed battery, like an HT battery pack with seven cells (8.4 volts nominal), stop the discharge when the battery reaches 7.0 volts, or 1.0 volt per cell average.

Fully charge the cells or battery as recommended and you're ready for the discharge capacity test. I connect a digital voltmeter to the jacks on the test load to monitor total voltage. If I'm testing an HT battery pack, this is the only voltmeter I'll need. If I'm testing a group of individual cells as shown in **photo D**, I use a second voltmeter to monitor and pull individual cells whenever they drop to 1.0 volt.

Turn on the test load and set for 1.2 A (for 1.2 Ah cells). Be sure to log in the start time, or use a stopwatch or timer. You'll have to readjust the test load as voltage drops to maintain a constant load. If the first cell takes 45 minutes or 0.75 hours to drop to 1.0 volt, multiply the 1.2 A load times 0.75 hours. The capacity of that cell is 0.9 Ah or 75 percent of rated capacity. I pull each cell as it reaches 1.0 volt and calculate its capacity. Use the same time/load procedure to discharge a battery pack, but stop when the volt-

age drops to 1.0 volt times the number of cells in the battery pack. The same quick calculation will give you the capacity of your battery pack.

I keep records on my cells and battery packs. The original, and only, battery pack for my TR2500 HT is almost 4 years old but still has over 80 percent of its original capacity. As cells get older, they may not hold 1.2 volts at load for as long, but may drop slowly to and through the 1.1-volt range. In other words, the cell can no longer hold the relatively flat discharge curve. Such cells may or may not be suitable, depending on the type of equipment in which they are used. In any case they are "suspect," and should be watched more closely than normal.

You may also want to let fully charged NiCds sit for up to 30 days, run a discharge test, calculate the capacity, and compare it to the capacity of the cells or battery when just charged. The results of age or premature self-discharge can be quite noticeable here.

Remember, your NiCds actually *like* this kind of testing. In fact, a couple of complete charge/discharge cycles may actually improve their capacity. And...you'll have the added benefit of knowing just what condition they're in!

References

1. H & R Corporation, 401 E. Erie Avenue, Philadelphia, Pennsylvania 19134.

Article J HAM RADIO



GREAT HOLIDAY GIFT IDEA

NOW BACK IN STOCK

HAM RADIO LOG BOOKS
back by popular demand!

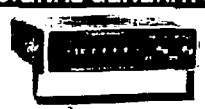
Room for over 2100 QSO—that's over twice as many as the other log books. For contesters, each page contains 30 QSO's for easy counts. You also get the latest up-to-date frequency spectrum chart. ITU callsign list and ARRL DXCC list. Spiral bound to lay flat on your desk. Unquestionably the best log book value around. 1988.

HR-LB.....Spiralbound $2.95
HR-3LB Special
Buy 3 Price. Save 22%.....Get 3 offer $6.95

VISA Please Add $3.50 for shipping and handling. MasterCard

HAM RADIO BOOKSTORE
GREENVILLE, NH 03048 (603) 878-1441

SYNTHESIZED SIGNAL GENERATOR



MADE IN USA

MODEL SG-100F $429.95 delivered

• Covers 100 MHz to 199.999 MHz in 1 kHz steps with thumbwheel dial • Accuracy +/– 1 part per 10 million at all frequencies • Internal FM adjustable from 0 to 100 kHz at a 1 kHz rate • External FM input accepts tones or voice • Spurs and noise at least 60 dB below carrier • Output adjustable from 5-500 mV at 50 Ohms • Operates on 12 Vdc @ ½ Amp • Available for immediate delivery • $429.95 delivered • Add-on accessories available to extend freq range, add infinite resolution, AM, and a precision 120 dB attenuator • Call or write for details • Phone in your order for fast COD shipment.

VANGUARD LABS
196-23 Jamaica Ave., Hollis, NY 11423
Phone: (718) 468-2720 Mon. thru Thu.

162

NEMAL ELECTRONICS

•Complete Cable Assembly facilities MIL-STD-45208
•Commercial Accounts welcome- Quantity pricing • Same day shipping most orders
•Factory authorized distributor for Alpha, Amphenol, Belden, Kings, Times Fiber

Call NEMAL for computer cable, CATV cable, Flat cable, semi-rigid cable, telephone cable, crimping tools, D-sub connectors, heat shrink, cable ties, high voltage connectors.

HARDLINE 50 OHM

FXA12 1/2" Aluminum Black Jacket	.89/ft
FLC12 1/2" Cablewave corr. copper blk jkt	1.69/ft
FLC78 7/8" Cablewave corr.copper blk jkt	3.92/ft
NM12CC N conn 1/2" corr copper m/f	25.00
NM78CC N conn 7/8" corr copper m/f	54.00

COAXIAL CABLES (per ft)

1180 BELDEN 9913 very low loss	.52
1102 RG8/U 95% shield low loss foam 11ga	.36
1110 RG8X 95% shield (mini 8)	.17
1130 RG213/U 95% shield mil spec NCV jkt	.39
1140 RG214/U dbl silver shld mil spec	1.85
1705 RG142B/U dbl silver shld, teflon ins	1.50
1310 RG217/U 50 ohm 5000 watt dbl shld	.98
1450 RG174/U 50 ohm .100" od mil spec	.14

ROTOR CABLE-8 CONDUCTOR

8C1822 2-18ga and 6-22ga	.21
8C1620 2-16ga and 6-20ga	.39

CONNECTORS-MADE IN USA

NE720 Type N plug for Belden 9913	$3.95
NE723 Type N jack for Belden 9913	4.95
PL259 standard UHF plug for RG8,213	.65
PL259AM Amphenol PL259	.89
PL259TS PL259 teflon ins/silver plated	1.59
PL258AM Amphenol female-female (barrel)	1.65
UG175/UG176 reducer for RG58/59 (specify)	.22
UG21DS N plug for RG8,213,214 Silver	3.35
UG83B N jack to PL259 adapter, teflon	6.50
UG146A SO239 to N plug adapter, teflon	6.50
UG255 SO239 to BNC plug adapter, Amphenol	3.29
SO239AM UHF chassis mt receptacle,Amphenol	.89

GROUND STRAP-GROUND WIRE (per ft.)

GS38 3/8" tinned copper braid	.40
GS12 1/2" tinned copper braid	.50
GS200 1-1/2" heavy tinned copper braid	2.00
HW06 6ga insulated stranded wire	.35
AW14 14ga stranded Antenna wire CCS	.14

Prices do not include shipping, $3 minimum, Visa/Mastercard $30 min, COD add $3.00
Call or write for complete price list. Nemal's new 36 page CABLE AND CONNECTOR SELECTION GUIDE is available at no charge with orders of $50 or more, or at a cost of $4 with credit against next qualifying order.

NEMAL ELECTRONICS, INC. 12240 NE 14th Ave. N. Miami, FL 33161
(305) 893-3924 Telex 6975377 24hr FAX (305)895-8178

HAM RADIO cumulative index 1984-1988

ANTENNAS AND TRANSMISSION LINES

general

Antenna insulators, PTFE VHF
W5JTL p 98, Oct 85
Antenna relay sequencing
KN5SS p 17, Oct 87
Antenna support (HN)
W6XM p 64, Jun 84
Applied Yagi antenna design part 2: 220 MHz and the Greenblum design data
WB3BGU p 33, Jun 84
Balun chop suey
K4KJ p 113, May 85
Bulkhead connector (HN)
K9CZB p 78, Apr 85
Short Circuit p 74, Jul 85
Compact travel antenna
K1BQT p 29, Jun 87
Construction techniques using PVC pipe to make antennas
W2OQI p 98, Sep 88
Direction-finding tool, the fox box
K1ZJH p 25, Oct 85
Easy measurement of antenna currents (HN)
KO1F p 39, Sep 88
Elmer's notebook: Standing wave ratio-what does it mean?
W1SL p 98, Feb 88
Groundplane antenna
Comments: DJ0TR/OE8AK p 6, June 87
Comments, ground plane antennas
W6BCX p 6, Oct 87
Ground rod resistance
K4MT p 95, Jul 84
Comments p 8, Sep 84
Ham Radio techniques
W6SAI p 75, Nov 84
Ham Radio techniques
W6SAI p 67, Dec 84
Ham Radio techniques: antenna systems
W6SAI p 55, May 87
Ham Radio techniques: A look at the groundplane antenna
W6SAI p 38, Oct 88
Homebrew antenna mount
W6QIR p 35, May 87
Leyden's magic jar: the derivation of the Hertzian and Marconi antennas
KR6A p 24, Oct 84
Preamplifiers, Active antenna
RW Burhans p 47, May 86
Practically speaking: using antenna noise bridge
K4IPV p 69, May 86
Secrets of successful low-band operation: part 1
K2RR p 16, May 86
Secrets of successful low-band operation: part 2
K2RR p 17, Jun 86
7/8-inch hardline coax connectors-construct at your own low cost
WA5FAC p 95, Sep 88
VHF/UHF world
W1JR p 110, May 84
VHF/UHF world
W1JR p 77, Sep 86
Wire plow, build a simple
W7IV p 107, May 84
Yagi design program
W6NBI p 6, May 87
Yagis, stacking is a science
K1FO p 18, May 85
Yagi vs Quad, part 1
K2SS p 68, May 88
Yagi vs Quad-part 2
K2SS p 78, Jun 88

hf antennas

Active antenna, 0.5-30 MHz
K1ZJH p 37, May 85
Comments, Hansen, R.C. p 10, Jul 85
Analyzing 80-meter delta loop arrays
K1GQ p 10, Sep 86
Applied Yagi antenna design, part 6: the model and a special teaching tool
WB3BGU p 89, Oct 84
Capacitively loaded dipole, high-performance
W6VX p 33, May 84
Delta loop, the reduced-size, full-performance, corner-fed
G3TKN p 67, Jan 85
Designing trap antennas: a new approach
W0JF p 60, Aug 87
Designing Yagis with the Commodore 64
N0CAO p 107, Jan 86
Elmer's notebook: ten-meter skyware
W1SL p 90, Jul 88
End-fed 8JK; switchable vertical array
W1JF p 53, May 85
Five-band dipole
W6HPH p 76, Sep 88
Ham Radio techniques
W6SAI p 65, Jan 84
Comments, WA2DRL p 8, Sep 84
Ham Radio techniques
W6SAI p 63, Feb 84
Comments, K4KYV p 12, May 84
Comments, WD6DUD p 8, Sep 84
Comments, AD1G p 8, Dec 84
Ham Radio techniques
W6SAI p 53, Mar 84
Ham Radio techniques
W6SAI p 76, Apr 84
Ham Radio techniques, fifty years ago
W6SAI p 58, Jun 84
Ham Radio techniques, 160 redux
W6SAI p 89, Jul 84
Ham Radio techniques
W6SAI p 96, Aug 84
Ham Radio techniques
W6SAI p 106, Oct 84
Ham Radio techniques
W6SAI p 55, Dec 85
Ham Radio techniques: time and frequency station WWVS, minibeam design, "white noise"
W6SAI p 37 Jun 87
Ham Radio techniques: 80-meter antenna, 160-meter discone antenna
W6SAI p 57 Jul 87
Ham Radio techniques: antennas
W6SAI p 57 Sep 87
Ham Radido techniques: "radio ground" on 160 meters
W6SAI p 53, Mar 88
Ham Radio techniques: why not a two-element Yagi
W6SAI p 36, May 88
Ham Radio techniques: a nifty bi-square beam for 10 or 12 meters
W6SAI p 68, Jun 88
How high should your HF antenna be
W5QJR p 89, May 86
Inverted "L", limited space (HN)
W8FR p 63, Jun 84
JR vari-lobe antenna, control your take-off angle
W1JF p 46, May 85
Matching dipoles (letter)
W5XW p 8, Aug 85
Modified Bobtail (HN)
W0MBP p 87, Sep 84
Multiband 8JK, an end-fed
G3SBA p 81, May 84
New class of directive antennas
W4MB p 107, Apr 86
Comment, AG4R p 9, Jul 86
No-compromise, multiband, low VSWR dipole
GM3HAT p 69 May 87
Odd antennas, comments
W9RXC p 9, Aug 86
Offset drooper: an improved ground plane
W6BCX p 43, Feb 86
Old antennas, comments
W0MBP p 9, Feb 86
Optimizing gain on Yagi antennas
K2SS p 21, Mar 88
Phased arrays, feeding:
KB8I p 58, May 85
Short circuit p 74, Jul 85
Quad antenna:part 1-general concepts
W4MB p 43, May 88
Quad antenna:part 2-circular and octagonal loops
W4MB p 54, June 88
Quad antenna:part 3-circular loop and octagonal arrays
W4MB p 34, Aug 88
Rhombics, controlled vertical radiation, part 1: designing for high performance
N4UH p 100, Mar 85
Rhombics, controlled vertical radiation, part 2: antenna erection and performance
N4UH p 99, Apr 85
Secrets of successful low-band operation: part 1
K2RR p 16, May 86
Secrets of successful low-band operation: part 2
K2RR p 17, Jun 86
SEED antenna: a short, efficient end-fed dipole
W4JAZ p 103, Sep 84
Shortened 40-meter four-element sloping dipole array
OE5CWL p 74, May 88
Structural evaluation of Yagi elements
K5IU p 29, Dec 88
Tapered vertical, calculating the input impedance of
K3OQF p 24, Aug 85
Short circuit p 78, Oct 85
Terminated vee beam, sloping
Ross, Robert p 71, May 85
Three-band sloper for 7, 18 and 24 MHz (HN)
W5FG p 58, May 88
Top-loaded vertical, a high-efficiency
W6US p 65, Oct 84
Transmission line antenna, 160-meter
N9NB p 87, May 85
Trap antenna, design your own
W4MB p 37, Oct 84
Two-element hf beams
G6XN p 8 May 87
Comments, W9OAM p 10, Mar 84
Two single 80-meter radiators for short and long skip (HN)
YO4WU p 98, Nov 88
Vertical phased arrays: part 6
K2BT p 45, May 84
Verticals over REAL ground
WB9VWA p 35, Jan 84
W2PV 80-meter quad
K1GO p 56, May 86
W8JK antenna for 40, 30 and 20 meters
N6YC p 9, May 88
Yagis, stacking is a science
K1FO p 18, May 85
3-element Yagi design, key to
K3OQF p 48, Mar 84
40, 80, and 160-meter vertical, remote controlled
W7LR p 38, May 84
80-meter half-wave sloper uses reflector (HN)
KO1F p 48, Oct 84
Short circuit p 8, Feb 85

vhf antennas

Antenna insulators, PTFE VHF
W5JTL p 98, Oct 85
Applied Yagi antenna design part 1: a 2-meter classic revisited
WB3BGU p 14, May 84
Applied Yagi antenna design part 2: 220 MHz and the Greenblum design data
WB3BGU p 33, Jun 84
Applied Yagi antenna design part 3: 432 MHz with Knadle and Tilton
WB3BGU p 73, Jul 84
Applied Yagi antenna design part 4: a 50-MHz Tilton/Greenblum design
WB3BGU p 103, Aug 84
Applied Yagi antenna design part 5: additional optimization techniques
WB3BGU p 93, Sep 84
Cofagi antenna, The
VE3BFM p 61, May 86
Computer-aided design of long VHF Yagi antennas
VK4ZF p 28, May 86
Cylindrical feedhorns revisited
WA9HUV p 29, Feb 86
Efficiently launch-VHF/UHF wave
W3HWC p 63, Oct 88
Fastening Trigon reflectors to VHF antennas (HN)
W5JTL p 88, Sep 84
Ham notebook: a 2-meter halo antenna
NR5A p 63, May 87
High-performance Yagis for 432 MHz
K1FO p 8, July 87
Short Circuit p 97, Oct 87
Comments: KLM balun
WMScott p, 6, Sept 87
Long 2-meter collinears—a simple way to achieve gain (HN)
WB3AYW p 5, May 86
VHF/UHF World
W1JR p 110, May 84
VHF/UHF World: stacking antennas, part 1
W1JR p 129, Apr 85
VHF/UHF World: stacking antennas, part 2
W1JR p 95, May 85
VHF/UHF world
W1JR p 85, Dec 85
VHF/UHF world: Designing and building loop Yagis
W1JR p 56, Sep 86
Short circuit p 54, Jan 86
VHF Yagi CAD on the C-64
W4PFZ p 70, Sep 86
VHF/UHF world: Yagi facts and fallacies
W1JR p 103, May 86
VHF/UHF world: optimized 2- and 6-meter Yagis
W1JR p 92, May 87
Short circuit p 41, Aug 87
Short circuit p 49, July 87

VHF/UHF world: minimum requirements for 2-meter EME-part 1
W1JR p 39, Aug 87
Yagi triangular array
W2IKP p.42, May 87
Yagi trigon reflector, Optimizing
WB3BGU p 84, Jan 86
Yagi, a high-gain 70-cm
W1JR p 75, Dec 86
Short circuit p 68, Feb 87
Yagis, stacking is a science
K1FO p 18, May 85
2-meter J-pole antenna, all-metal
KD8JB p 42, Jul 84
Comments, K2WWT,
KD8JB p 8, Feb 85
Comments, DJØTR/OE8AK p 8, Nov 85
2-meter V-antenna
AD1B p 86, Jan 84

matching and tuning

Antenna matching, easy
WB4GCS p 67, May 84
Broadband RF transformers
K2LB p 75, Jan 86
Designing trap antennas: a new approach
WØJF p 60 Aug 87
Elmer's notebook:antenna tuner
W1SL p 83, Apr 88
Elmer's notebook: antenna tuner
W1SL p 102, May 88
Gamma matching, basic
WBØKN p 29, Jan 85
Gamma matching programs for the C-64/128
NØCAO p 87, May 87
Ham radio techniques
W6SAI p 65, Jan 84
Comments, WA2DRL p 8, Sep 84
Ham radio techniques
W6SAI p 63, Feb 84
Comments, K4KYV p 12, May 84
Comments, WD6DUD p 8, Sep 84
Comments, AD1G p 8, Dec 84
Ham Radio techniques:"radio ground" on 160 meters
W6SAI p 53, Mar 88
Improving operation with the MFJ 989 transmatch (Weekender)
W4RNL p 24, Nov 88
Matching dipole antennas
W1ØLP p 129, May 84
Comments, W5XW p 12, Apr 85
Phased arrays, feeding: an alternative method
KB8I p 58, May 85
Short circuit p 74, Jul 85
Pi network equations
K4MT p 109, Oct 88
Practically speaking: impedance matching
K4IPV p 27, Aug 88
Remote tuner for 75-meter mobiles (weekender)
K9MLD p 36, Oct 88

towers and rotators

Antenna tower, fixed, tilt-over conversion
PAØSE p 125, May 85
AUTOTRAK, a simple rotor interface board for the C-64, VIC-20 and applicable to other popular computers
K7NH p 10, Dec 87
Ham notebook: simple tower guards
K1ZJH p 39, Sept 88
Match your antenna to your tower
WDØOGF p 14, Jun 84
Tower installation: make it sturdy, make it safe
WB5IIR p 22, Jun 84
Turning that big array
VE3AIA p 10, Jun 86
Keep your tower up
KB9IW p 26, Jun 84
UHF antenna tower, low-cost
KA6GVY p 30, Oct 84

transmission lines

Artificial Transmission lines
KA8OBL p 21, Jul 86
Bridge measurements, the half-wave transmission line in (HN)
K4KI p 108, Nov 84
Elmer's notebook: transmission lines
W1SL p 90, Mar 88
General purpose line transformers
W6IOJ p 94, Aug 86
Ham radio techniques, fifty years ago
W6SAI p 58, Jun 84
Measuring transmission line parameters
OE2APM/AA3K p 22, Sept 88
Open-wire line for 2 meters
N4UH p 94, Jan 87
Practically speaking: transmission lines and their typical AC responses
K4IPV p 34, Sept 88
Practically speaking: standing waves-a review
K4IPV p 85, Oct 88
Real coax: impedance and phase relationships
K2BT p 8, Apr 87
Short circuit p 91, July 87
Practically speaking: amplifier tuning problem
K4IPV p 78, Nov 86
Real coax: impedance and phase relationships
K2BT p 8, Apr 87
Short circuit p 91, Jul 87
RF transmission cable, microwave applications
K3HW p 106, May 85
Solving transmission line problems on your Commodore 64
K9CZB p 74, May 86
Short circuit p 87, Jul 86
VHF/UHF World-transmission lines
W1JR p 83, Oct 85
Comments W9ICZ p 9, Apr 86
VHF/UHF World
W1JR p 85, Dec 85

AUDIO

Advanced CW processor
W6NRW p 25, Dec 86
Audio Filter design, computer-aided
KE2J p 15, Oct 85
Audio filter design, elliptic lowpass
W3NQN p 20, Feb 84
Audio oscillator to pulse generator conversion (HN)
WØDLQ p 50, Oct 84
Audio to microwave amplifier, build your own
Gruchalla, Michael p 12, Mar 84
Aural vco provides relative metering
K1ZJH p 97, Jan 87
Automatic gain control, an audio
K7NM p 24, Sep 84
Build a QSO "beeper"
KF6CU p 38, Jan 88
Code practice oscillator (weekender)
N2DCH p 65, Oct 88
Converting mobile microphones for handheld VHF transceivers
KD8KZ, WB3JCC p 79, Mar 86
Short circuit p 199, Aug 84
Extended-range VU meter
WB6JNN p 59, Sep 86
Improving the audio on the ICOM IC-27
KD8KZ p 61, Feb 86
Modifying microphones
VE7CB/W6 p 81, Jan 87
Passive audio filter design, part 2: highpass and bandpass filters
Niewiadomski, S p 41, Oct 85
Comments, W3NQN p 8, Nov 85
Passive audio filter design: part 3
Stefan Niewiadomski p 29, Jan 86
Phone patches, building and using
N6ARE p 34, Oct 85
Power speaker enhances mobile operation
K1ZJH p 83, Jan 88
Processor for code tapes
W4ULD p 61, Sept 88
Repeaters, speech synthesis for
N9EE p 79, Mar 84
Sight and souud CW
W6NRW p 10, Jan 88
Telephone ring indicator, visual (HN)
W2QLI p 62, Apr 84
Understanding telephones
N6ARE p 39, Sep 85
Comments, KD7WL p 9, Apr 86

COMMERCIAL EQUIPMENT

Annunciator bell for the Kantronics KPC-2
K1ZJH p 22, Aug 86
Argonaut 509 conversion for 30 meters (HN)
AA4LL p 49, Oct 84
C-64 and GLB PK-1 interface circuit
W2EHD p 87, Mar 87
CAT control system for the Yaesu FT-757GX
SM6CPI p 26, Nov 87
Computer control of ICOM R-71, 271, 471, and 751 radios
NG6Q p 47, Apr 86
Extending receive coverage for the IC-02 and IC-04
WB6GTM p 77, Jul 86
Comments: WB6GTM p 6, May 87
Ham radio techniques
W6SAI p 63, May 84
Ham radio techniques, fifty years ago
W6SAI p 58, Jun 84
Ham Radio Techniques: "white noise" revisited
W6SAI p 79, Oct 87
ICOM's newest transceiver
N1ACH p 17, Mar 88
Improved gain distribution for the Yaesu FT-726R
K1ZJH p 53, July 87
Comments: Kudos for Kantronics
WB3EXR p 6, June 87
Improving the audio on the ICOM IC-27
KD8KZ p 29, Jan 86
KWM2, RIT for the (HN)
KH6JF p 109, Jul 84
Modifying the Trio-Kenwood TS-930S
WB9BXT p 67, Apr 86
Modifying the Yaesu FT-301 for 30-meter coverage
AF9Q p 42, Mar 86
More fixes for the IC22S VHF radio
VE6ZS p 91, Oct 88
More optional notes on the TS-930S
W6FR p 23, Apr 88
Practically speaking: now that the warranty has expired
K4IPV p 67, Sep 85
Comments, W5QJM p 8, Nov 85
RDF, An improved
KØOV p 67, July 87
Simple IC-735 to C-64 interface
N7ICW p 39, Mar 87
Simple modifications and adjustments for the TS-930S
W6FR p19, Apr 87
Technology of commercial television part 2: hardware
KL7AJ p 54, Jan 88
Ten-Tec Corsair modification (HN)
N3BEK p 62, Apr 84
Thumbwheel frequency selector for the Yaesu FT-757GX
KA9SNF p 33, Nov 87
TR-2500/2600 2-channel programming (HN)
K9MLD p 128, Oct 85???IF filter mod (HN)
KBØCY p 125, May 84
TS-930S headset audio, increased undistorted (HN)
W6FR p 128, Oct 85
Using an RTTY terminal unit with the Heathkit HD4040 TNC
AA8V p 59, Aug 86

COMPUTER-AIDED DESIGN

Bandpass filter design, interdigital, computer-aided
N6JH, Monemzadeh p 12, Jan 85
Short circuit p 117, Jun 85
Computer-aided design of long VHF Yagi antennas
VK4ZF p 28, May 86
Design a no-tune amplifier with your personal computer
W7DHD p 8, Sep 87
Designing Yagis with the Commodore 64
NØCAO p 107, Jan 86
Diagnostic serial data latch
KA9SNF p 56, Apr 88
Direct currents reduce core permeability
K5BVM p 58, Jul 86
Short circuit p 87, Jul 86
Elmer's notebook: modems and RS-232
W1SL p 113, Oct 88
Gamma matching programs for the C-64/128
NØCAO p 87, May 87
Ham notebook: rebuild your C-64 keyboard with C-? parts
AF8B p 74, Feb 88
Linear design by computer
W4MB p 37, Feb 87
Low-cost pc board layout software
Freeman, Eva p 8, Oct 87
Remote repeater programming using a computer and a telephone
KD9BC p 89, Mar 86
RF filters, Build narrowband
WB4EHS p 10, Mar 86
Short circuit p 36, Jun 86
Solving transmission line problems on your Commodore 64
K9CZB p 74, May 86
Top-down filter design
VE5FP p 41, Jan 87
VHF Yagi CAD on the C-64
W4PFZ p 74, May 86
Comments: Yagi design program
W6NBI p 6, May 87
Yagis, designing with the Commodore 64
WA3EKL p 59, Jun 85

CONSTRUCTION TECHNIQUES

Advanced CW processor
W6NRW p 25, Dec 86
Air-wound coils, constructing
W7BKE p 37, Aug 84
Battery charger, NiCd, constant current, a pulsed
K2MWU p 67, Aug 85
Build a better box
Gruchalla, Michael p 45, Aug 84
Build narrowband RF filters, Comments
WB4EHS p 9, Sep 86
Bulkhead connector (HN)
K9CZB p 78, Apr 85
Short circuit p 74, Jul 85
Carpet samples in the ham shack
K1ZJH p 82, Sep 87
Code practice oscillator
N2DCH p 65, Oct 88
Construction techniques using PVC pipe to make antennas
W2OQI p 98, Sept 88
Cooling semiconductors part 1: designing and using heatsinks
Martin, Vaughn D p 33, Jul 84
Cooling semiconductors part 2: blowers and fans
Martin, Vaughn D p 52, Aug 84
Design an amplifier around the 3CX1200A7
W7DHD p 33, Dec 87
DTMF tone signaling circuit
WV6A p 42, Sept 88
Dummy load, DC
W4MLE p 91, Apr 85
Elevation indicator, inexpensive
W5JTL p 67, Jun 85
Elmer's notebook: the mysterious "Q"
W1SL p 110, Sept 88
Get the most from your NiCds (Weekender)
K3OF p 88, Dec 88
G.O.E.S. reception: a simple approach
WA4WDL p 46, Jan 84
Ham notes: Waterproofing fittings
W4MLE p 101, Nov 86
High-frequency dummy load (HN)
W1KWE p 64, Jun 84
Homebrew tuning dial
N2DCH p 75, Dec 88
Homebrewing equipment from parts to metal work
W7KBE p 26, Mar 88
Inductance equation, a different approach (HN)
K4KI p 116, Dec 84
Junk-box ingenuity; how to buy, use, and recycle surplus electronic parts
WB4EHS p 32, Aug 84
Low-cost pc board layout software
Freeman, Eva p 8, Oct 87
Make a homebrew sheet metal brake for chassis construction projects
WB6BIH p 43, Jun 86
Microstrip impedance program
K8UR p 84, Dec 84
NE5205 wideband amplifier
Gruchalla p 30, Sep 86

Short circuit p 72, Jan 87
New uses for old tuners
W6WTU p 25 Jan 88
Passive audio filter design, part 1: development and analysis
Niewiadomski, S p 17, Sep 85
Polymer film transforms mechanical energy to electrical energy
WA4KFZ p 55, Dec 84
Power FETs: trend for VHF amplifiers
Peters, Daniel and W7PUA p 12, Jan 84
Practically speaking: Keep it cool
K4IPV p 75, Apr 86
Practically speaking: parts sources
K4IPV p 78, Nov 86
Practically speaking: grounding and shielding, pt 1
K4IPV p 47, Apr 87
Practically speaking: grounding and shielding, pt. 2
K4IPV p 81, May 87
Comments: grounding and shielding
KA8DKT p 6, Aug 87
Practically speaking: drift and shift
K4IPV p 75, Jan 88
Practically speaking: noise, signals and amplifiers
K4IPV p 77, Feb 88
Practically speaking: feedback
K4IPV p 60, May 88
Practically speaking: "ferriting" out the problem
K4IPV p 72, Jun 88
Practically speaking: non-ideal lianear IC amplifiers typical problems and how to solve them
K4IPV p 72, Jul 88
Practically speaking: Overview of op amps-part 1
K4IPV p 100, Nov 88
Practically speaking: Overview of op amps-part 2
K4IPV p 83, Dec 88
Precision high-voltage dc regulator
AG6K p 75, Aug 88
Quick fix for soldering irons (HN)
W2YW p 62, Apr 84
Reflected power limiter
K4KI p 63, Jul 84
Remote base/simplex phone patch controller
AA4NX and KK4LA p 54, Aug 88
Rewinding transformers with CAD
W6WTU p 74, Mar 87
RF filters, Build narrowband
WB4EHS p 10, Mar 86
Short circuit p 36, Jun 86
Silk screen techniques, make your own board using
W3QOM p 83, Nov 84
Silverplating, safe, sensible
K9EYY p 29, Feb 85
Simple low-cost comb generator frequency calibrator
Martin, Larry p 78, Jul 88
Simple receivers from complex ICs
W6VEH p 10, Nov 88
Solar power for your ham station
NH6N p 14, Dec 84
Structural evaluation of Yagi elements
K5IU p 29, Dec 88
Superhet coilset, design with a microcomputer
Sterrenburg, FAS p 113, Nov 84
The Guerri report: pc boards
W6MGI p 109, Sep 86
Tuning indicator for RTTY and packet radio
W0HZR p 65, Sept 88
Two in one: trace doubler for CRO, and square wave and pulse generator (HN)
Tseng Liao p 26, Dec 88
2-meter monitor
WA3ENK p 64, Jul 88
Universal analog breadboard, A
Gruchella, Michael p 85, Jun 86
ZX-81/TS1000 controller: new use for old computers
N9NB p 31, Dec 86

DIGITAL TECHNIQUES

Add a digital readout to the "poor man's spectrum analyzer"
WA2PZO p 84, Sept 88
Amateur FSK: A spectral analysis
WA6NCX p 42 Dec 86
AMTOR, AX.25, and HERMES: a performance analysis of three systems
W9JD p 63, Dec 85
Comments, G3PLX p 9, May 86
Annunciator bell for the Kantronics KPC-2
K1ZJH p 22, Aug 86
Audio filter design, computer-aided
KE2J p 15, Oct 85
AUTOTRAK, simple rotor interface board for the C-64, VIC-20 and applicable to other popular computers
K7NH p 10, Dec 87
Build a QSO "beeper"
KF6CU p 38, Jan 88
CAT control system for the Yaesu FT-757GX
SM6CPI p 26, Nov 87
Commodore 64, $100 printer (HN)
W2QLI p 86, Aug 85
Computer control of ICOM R-71, 271, 471, and 751 radios
NG6Q p 47, Apr 86
Comments: Continuous phase tones
G3VMR p 6, Aug 87
Decoding data signals
WB4GCS p 60, Dec 88
Deluxe logic probe
MWilde p74, Jan 87
Digital can do more, Comments
KA4JFO p 9, Mar 86
Digital clock, build a fail-safe
K1MC p 54, Oct 85
Digital frequency readout using the Commodore 64
W3NNL p 83, Nov 85
Digital HF radio: a sampling of techniques
KA2WEU/DJ2LR p 19, Apr 85
Short circuit p 121, May 85
Direct synthesis VFO
W7SX p 10, Sept 88
DTMF controller for repeaters
WB4FXD p 47, Sep 85
DTMF tone signaling circuit
WV6A p 42, Sept 88
Elmer's notebook: An introduction to digital communications
W1SL p92, Jul 87
Elmer's notebook: An introduction to AMTOR
W1SL p 101, Sept 87
Elmer's notebook: packet radio
W1SL p 100, Oct 87
Frequency synthesis up to 2 GHz
WA6DYW p 22, Apr 88
Get on SSTV-with the C-64
I2CAB and I2AED, edited by K9EI p 43, Oct 86
Short Circuit p 97, Oct 87
HP-IL serial loop
Martin, Vaughn D p 101, Apr 84
Improving the WB3CEH programmable callsign identifier (hn)
KL7XO p 82, Sept 87
Comments: Packet board update
VE3LNY p6, Jan 87
Packet radio and area networking
WB3JZO p 38, Dec 84
Packet radio, automatic frequency and deviation tester
WB2OSZ p 41, Dec 85
Packet radio primer
WA1FHB p 30, Dec 85
Packet radio: the software approach
W4UCH p 63, Sep 84
Packet radio TNC for the IBM PC
VE3LNY p 10, Aug 86
PL tone generator, a programmable
WB0VSZ p 51, Apr 84
Short circuit p 125, May 84
Practically speaking: using the digital frequency counter-some pitfalls
K4IPV p 47, Apr 88
RAM drive for packet radio
AD1B p 44, Dec 87
RTTY reader, interrupt-driven
KN4L p 72, Sep 84
Run RTTY on your Timex
NU4V p 110, Apr 85
Run RTTY on your VIC-20
W5TRS p 120, Apr 85
Satellite tracker, digitally-controlled
KA8OBL p 102, Sep 85
Smith Chart impedance matching on your Commodore 64
WA9GFR p 120, Oct 84
Software piracy (letter)
Forsyth, Mike p 8, Sep 84
Spread spectrum and digital communication techniques: a primer
N9NB p 13, Dec 85
The Guerri report computer technology
W6MGI p 54, Nov 84
Short circuit p 8, Dec 84
The Guerri report: signal processing
W6MGI p 156, Dec 84
The Guerri report
W6MGI p 124, Jan 86
The Guerri report
W6MGI p 125, Apr 86
Thumbwheel frequency selector for the Yaesu FT-757GX
KA9SNF p 33, Nov 87
True frequency digital readout for the HW-101, A
NU4F p 8, Jan 87
Short circuit: p 41, Aug 87
Using an RTTY termi???h the Heathkit HD 4040 TNC
AA8V p 59, Aug 86
VIC-20 printer (HN)
W2QLI p 88, Sep 84

FEATURES AND FICTION

Electromagnetic jargon generator, state-of-the-art
N6TX p 75, Apr 85
Ham radio techniques: Ever work a W10
W6SAI p 43, Feb 87
Short circuit: p 50, Apr 87
Ham radio techniques: Xingiang Province the last frontier
W6SAI p 55, Apr 87
Ham Radio techniques: the year was 1923...
W6SAI p 89, Jan 88
Ham Radio techniques: "the greatest little magazine in the world"
W6SAI p 68, Feb 88
One hundred years of electric waves
KR6A p 22, Aug 88
Radio addiction: case history of an enthusiast
W7SX p 52, Jan 88
Reflections: Returning the spectrum to chaos. .courtesy of the FCC (General docket 87-389)
W9JUV p 6, Feb 88
Reflections: Novice enhancement and the future of amateur radiod
W9JUV p 6, Jun 88

FILTERS

Simple VHF/UHF multiple quarter-wave filters
WA3EWT p 37, Sept 87
Automatically switched half-octave filters: part 1
WB3JZO and Watkins, Lee R. p 10 *Feb 88*
Automatically switched half-octave filters: part 2
WB3JZO and Watkins, Lee R. p 29 Mar 88
Top-down filter design
VE5FP p 41, Jan 87

FM AND REPEATERS

DTMF controller for repeaters
WB4FXD p 47, Sep 85
FM advantage
WA9GDZ6 p 38, Sep 84
FM repeater separation 20 kHz. Yes, 15 kHz, No
WD5IBS p 12, Aug 85
Improved repeater/transmitter noise performance (HN)
K1ZJH p 104, Apr 86
Remote repeater programming using a computer and a telephone
KD9BC p 89, Mar 86
Repeater, high-tech: designing and building an FM translator
WA6CAY p 82, Feb 85
Repeaters, speech synthesis for
N9EE p 79, Mar 84
Repeaters, three circuits for (HN)
N9EE p 91, Jan 84
Short circuit p 10, Feb 84
Short circuit p 10, Mar 84
Tone burst generator for European repeaters, A
WA3EEC p 88, Jul 86
ZIA connection: a multi-state 2-meter repeater link
K5XY p 30, Oct 86

HAZARDS

AC line transient protection
N6JH p 59, Apr 86
Electric shock, the effects and treatment of
NY6U p 85, Mar 84

INTEGRATED CIRCUITS

Low-pass filter, integrated circuit
WB2KTG p 59, Jan 85
Static electricity and modern integrated circuits
K4KEF p 33, Mar 84
The Guerri Report: superchips come of age
W6MGI p 126, Feb 85
The Guerri report:
W6MGI p 124, Jan 86
The Guerri report: microchips
W6MGI p 109, Jul 86

KEYING AND CONTROL

Call sign identifier: programmable
WB3CEH p 33, Feb 85
Ham radio techniques
W6SAI p 106, Oct 84
Improving the WB3CEH programmable call sign identifier
KL7XO p 82, Sep 87
Keyer, simple, compact QRP (weekender)
W5FG p 82, Oct 84
Micros and VHF beacons transmit messages automatically
K9EI p 51, Jul 85
Morse Code tutor
N3SE p 45, Jun 85
Morse keyboard, an easier approach to mastering the
W1KZ p 80, Apr 84
Remotely controlled stations: a look at a *successful remote* base
WA6EJO p 48, Sep 86

MEASUREMENTS AND TEST EQUIPMENT

Add a digital readout to the "poor man's spectrum analyzer"
WA2PZO p 84, Sept 88
An i-f sweep generator
W2ZUC p 101, Jan 87
An rf voltmeter
G4COL p 65, Nov 87
Bridge measurements, the half-wave transmission line in (HN)
K4KI p 108, Nov 84
Build this simple L-C checker
W5FG p 19, Dec 88
Calibrating series-resistance capacitance bridges (HN)
Caron p 27, Dec 88
Continuity tester, simple
WD6GMB p 130, Sep 85
Deluxe logic probe, A
M. Wilde p 74, Jan 87
Detailed look at probes
Martin, and Davis p 75, Sep 85
Detector, logarithmic, wideband
PA0CX/DJ0SA p 75, Jul 85
Dual wattmeter, 50-500 MHz
WB4EHS p 67, Jul 85
Elmer's notebook: power measurements
W1SL p 100, Jan 88
Elmer's notebook: standing wave ratio-what does it mean?
W1SL p 98, Feb 88
EMI/RFI shielding: new techniques part 1
Martin, Vaughn D. p 72, Jan 84
EMI/RFI shielding: new techniques part 2
Martin, Vaughn D. p 85, Feb 84
Extended-range VU meter
WB6JNN p 59, Sep 86

Field strength meter, sensitive
K4KI p 51, Jan 85
Filter tester, simple (HN)
W6XM p 116, Dec 84
Frequency calibration using 60 kHz WWVB
W4ZPS p 45, Mar 68
Frequency counter, "smart"
WA5VOK p 41, Oct 84
Short circuit p 126, Apr 85
Frequency and level standard
PA0CX p 10, Jan 86
Comments, WA8LLY p 9, Jun 86
Ground rod resistance
K4MT p 95, Jul 84
Comments p 8, Sep 84
Ham radio techniques: time and frequency station WWVS
W6SAI p 37, Jun 87
High-frequency receiver performance
G4OBU p 33, Feb 84
HP-IB greatly simplified
Martin, Vaughn D. p 65, Mar 84
IF sweep generator, compact
PA0CX/DJ0SA p 35, Jun 85
L and C measurements
WB6ZLN p 117, Oct 84
Low-cost spectrum analyzer with Kilobuck features
W4UCH p 82, Sep 86
Measuring noise figure
K2BLA p 26, Jan 84
Microphone calibration
NY6U p 73, Jun 84
Multi-featured function generator
WA7IRY p 9 Apr 88
NBS time and frequency survey
NBS p 45, Jun 87
Ode to older oscilloscopes
KR6A p 69, Jan 88
Ohmmeter, wide-range
Bailey, John T p 53, Jan 84
Practically speaking
K4IPV p 79, Dec 85
Practically speaking: using the right multimeter
K4IPV p 95, Jun 86
Practically speaking: using the multimeter
K4IPV p 43, Jul 86
Practically speaking: using antenna noise bridge
K4IPV p 69, May 86
Practically speaking: function generator circuits-part 2
K4IPV p 89, Jan 87
Practically speaking: testing diodes
K4IPV p 65, Feb 87
Practically speaking: building "the poor man's spectrum analyzer:
K4IPV p 99, Mar 87
Practically speaking: build your own time-domain reflectometer
K4IPV p 69, Jun 87
Practically speaking: revisiting "the poor man's spectrum analyzer"
K4IPV p 49, Sep 87
Practically speaking: troubleshooting dc power supplies with anoscilloscope
K4IPV p 57, Oct 87
Practically speaking: using voltage comparators
K4IPV p 49, Nov 87
Practically speaking: generating low i-f frequencies
K4IPV p 49, Dec 87
Practically speaking: using the digital frequency counter-some pitfalls
K4IPV0- p 47, Apr 88
QRP wattmeter (HN)
W6XM p 110, Jul 84
Receiver sweep alignment system
WB6BIH p 124, Nov 84
Reflected power limiter
K4KI p 63, Jul 84
Sensitive LF or HF field-strength meter
K1RGO p 67, Sep 86
Simple low-cost comb generator frequency calibrator
Martin, Larry p 78 Jul 88
Test DBMs for diode leakage
WB6BIH p 66, Jun 87
The Guerri report: signal processing
W6MGI p 156, Dec 84
Transmitter tuning aid: buffer your load with this resistive network (weekender)
K4KI p 52, Feb 84
Comments, K4KI p 11, Jan 84
Tuneup, safe, silent
K4KI p 123, Dec 84
Two in one: Trace doubler for CRO, and square wave and pulse generator (HN)
Tseng Liao p 26, Dec 88
Two-tone signal generator
YB9ATA/WA7AQN p 25, Feb 86
Short circuit p 45, Apr 86
Short circuit p 36, Jun 86
23 GHz prescaler
N6JH p 21, Jan 87
Understanding noise figure
Gruchalla, M. p 89, Apr 87
VHF noise bridge, a
OE2APM/AA3K p 10, Jul 86
VHF/UHF world
W1JR p 55, Oct 84
SWR bridges
K2LB p 37, Mar 86
Wide-range RF power meter
KA8OBL p 24, Apr 86

MISCELLANEOUS TECHNICAL

ALC circuits, improving amplifier: part 1
WA8AJN p 40, Aug 84
ALC circuits, improving amplifier: part 2
WA8AJN p 38, Sep 84
Amateur FSK: A spectral analysis
WA6NCX p 42, Dec 86
Audio to microwave amplifier, build your own
Gruchalla, Michael p 12, Mar 84
Bicycle-powered station
W1BG p 25, Dec 84
Branch-line hybrid: part 1
WA2EWT p 107, Apr 84
Branch-line hybrid: part 2
WA2EWT p 93, May 84
Broadband amplifier-attenuator
W7SX p 59, Jul 86
Build a 1-1000 MHz amplifier using MAR-4 MMICs
WB6BIH p 33, Jul 87
Build a QSO "beeper"
KF6CU p 38, Jan 88
Buying topo maps, Comments:
K3SKE p 9, Dec 86
Can I patent it?
K2LZ p 8, Mar 87
Comments: changing fundamental constants of science
W4SXK p 6, Oct 87
Communicating on 474,083 GHz (light wave communications)
WA6EJO p 10, Dec 86
Decibel, defining the
Gruchalla, M p 51, Feb 85
Electromagnetic interference and the digital era
K3PUR p 114, Sep 84
Elmer's notebook: The mysterious "Q"
W1SL p 110, Sept 88
EMI/RFI shielding: new techniques part 1
Martin, Vaughn D. p 72, Jan 84
EMI/RFI shielding: new techniques part 2
Martin, Vaughn D. p 84, Feb 84
Filter design, graphic
W6NRW p 37, Apr 84
Short circuit p 13, Jul 84
Function Generator: circuits from your signal generator-part 1
K4IPV p 67, Dec 86
Ham Radio techniques
W6SAI p 63, May 84
Ham Radio techniques, fifty years ago
W6SAI p 58, Jun 84
Ham Radio techniques
W6SAI p 106, Oct 84
Ham Radio techniques
W6SAI p 75, Jan 85
Ham Radio techniques
W6SAI p 59, Feb 85
Ham Radio techniques
W6SAI p 83, Mar 85
Ham Radio techniques: electron-hole theory exposed as fraud
W6SAI p 67, Apr 85
Ham Radio techniques
W6SAI p 66, May 85
Ham Radio techniques
W6SAI p 51, Jun 85
Ham Radio techniques
W6SAI p 59, Jul 85
Ham Radio techniques
W6SAI p 90, Aug 85
Ham Radio techniques: I have seen the future and it works
W6SAI p 91, Sep 85
Ham Radio techniques
W6SAI p 75, Oct 85
Ham Radio techniques
W6SAI p 67, Nov 85
Ham Radio techniques: 9CXX revisited
W6SAI p 83, Dec 87
Ham Radio techniques: line voltage and power tube life
W6SAI p 60, Jul 88
Ham Radio techniques: the joys of TVI or, were you on the air last night?
W6SAI p 70, Aug 88
Harmonics, Trapping stubborn
N1RC p 99, Jan 66
Impedance matching: a brief review
WD4C p 49, Jun 84
Intermittent reception due to lightning (HN)
W2YW p 39, Sep 88
Lightning location and detection
VY1CW p 25, Sep 87
Linear amplifier, 3CX800A7
K8RA p 17, Aug 84
Low-pass filter, integrated circuit
WB2KTG p 59, Jan 85
Mobile theft deterrent: The Weekender
W6WTU p81, Feb 87
Modifying the Trio-Kenwood TS930S
WB9BXT p 67, Apr 86
Monolithic RF amplifiers
N6JH p 22, Mar 86
NE5205 wideband RF amplifier
Gruchalla, Michael p 30, Sep 86
Short circuit: p 72, Jan 87
Neutralizing 572B final at 1500 watts output (HN)
W2YW p 63, Jun 84
New uses for old tuners
W6WTU p 25, Jan 88
Noise cancellation circuit
K1RGO p 75, Mar 84
Peaked lowpass: a look at the ultraspherical filter
W7ZOI p 96, Jun 84
Phase modulator, PLL (HN)
VE3FHM p 117, Jun 85
Comments, K6KVX, Sample Martin, WD8AHO, WB4APT p 10, Feb 84
Polymer film transforms mechanical energy to electrical energy
WA4KFZ p 55, Dec 84
Power FETs: trend for VHF amplifiers
Peters, Daniel, and W7PUA p 12, Jan 84
Power speaker enhances mobile operation (weekender)
K1ZJH p 83, Jan 88
Practically speaking: repairing flood damage
K4IPV p 95, Oct 85
Practically speaking: intermittents, pt. 1
K4IPV p 75, Nov 85
Practically speaking: intermittents, pt. 2
K4IPV p 79, Dec 85
Practically speaking: battery problems, pt. 1
K4IPV p 62, Jul 87
Practically speaking: feedback
K4IPV p 60, May 88
Practically speaking: Overview of op amps-part 1
K4IPV p 100, Nov 88
Practically speaking: overview of op amps-part 2
K4IPV p 83, Dec 88
Prerecorded messages help the hearing impaired (HN)
W2QLI p 87, Sep 84
Quartz crystal resonators
Boddaert, Peter p 85, Feb 86
Remedy for RFI (comment)
K6WX p 9, Jul 88
Resonant circuits
WD4C p 12, Apr 84
RFI filters, Build narrowband
WB4EHS p 10, Mar 86
Short circuit p 36, Jun 86
RFI, solving the problems of
W2YW p 124, Sep 84
Russian Woodpecker, the: a continuing nuisance
KR7L p 37, Nov 84
Solar power for your ham station
NH6N p 14, Dec 84
Short circuit p 145, Mar 85
The Guerri report computer technology
W6MGI p 54, Nov 84
Short circuit p 8, Dec 84
The Guerri report
W6MGI p 124, Jan 85
The Guerri report: superchips come of age
W6MGI p 126, Feb 85
The Guerri report
W6MGI p 158, Mar 85
The Guerri report
W8MGI p 157, Apr 85
The Guerri report: a busy signal from space
W6MGI p 165, May 85
The Guerri report predicting equipment failure
W6MGI p 125, Jun 85
The Guerri report
W6MGI p 124, Jul 85
The Guerri report
W6MGI p 124, Aug 85
The Guerri report: RF power supplies achieve high efficiency
W6MGI p 157, Sep 85
The Guerri report: RF effects the good and the bad
W6MGI p 142, Oct 85
The Guerri report
W6MGI p 140, Nov 85
Two-tone signal generator
YB9ATA/WA7AQN p 25, Feb 86
Short circuit p 45, Apr 86
Short circuit p 36, Jun 86
Comments: "Using the Spectrum Monitor"
KI6DW p 9, Nov 86
Using CAD to rewind transformers
W6WTU p 83, Dec 86
Using spreadsheet programs
AD1B p 95, Dec 86
Very sensitive LF or HF field-strength meter
K1RGO p 67, Sep 86
VHF/UHF world: the VHF/UHF primer an introduction to filters
W1JR p 112, Aug 84
VHF noise bridge
OE2APM/AA3K p 10, Jul 86
VSWR bridges
K2LB p 37, Mar 86
Wide-range RF power meter
KA8OBL p 24, Apr 86

NOVICE READING

Cheers from down under, Comments:
VK4QA p 9, Dec 86
Ham radio technique
W6SAI p 59, Dec 86
Elmer's notebook: novice enhancement
W1SL p 95, Jun 87
Short circuit p 95, Aug 87
Elmer's notebook: 220 MHz
W1SL p 91, Aug 87
Elmer's notebook:an introduction to AMTOR
W1SL p 101, Sep 87
Elmer's notebook: packet radio
W1SL p 100, Oct 87
Morse code computer tutor
N3SE p 45, Jun 85
New band privileges for Novice operators (letter)
KA0DOE p 15, Sep 85
Comments, W3YBF p 9, Jan 86
Comments, KD0EV p 9, Jan 86
Comments, WD5H p 9, Jun 86
Novice privileges (letter)
WB9IVR p 9, Oct 85
Practically speaking
K4IPV p 79, Dec 85
Radiotelegraph codes: there's not just one
KR6A p 82, Sept 88
Reflections: Novice enhancement and the 220 MHz band
W9JUV p 4, Apr 87

OPERATING

Buying topo maps, Comments:
K3SKE p 9, Dec 86
Carrier complaint (comment)
WD0P p 9, Jul 88
Carrier-operated CW reception limiter
W6NRW p 113, Sep 85
Comments: DARC awards information
K1RH p 6, Jul 87
Elmer's notebook: 220 MHz
W1SL p 91, Aug 87
Short circuit p95, Aug 87
Elmer's notebook: an introduction to AMTOR
W1SL p 101, Sep 87
Elmer's notebook: packet radio
W1SL p 100, Oct 87
Elmer's notebook: "Q" signals
W1SL p 95, Jun 88
Field Day-prepardedness or party time? (Backscatter)
W9JUV and N1ACH p 6, Sept 88

Generation gap in Amateur Radio (comment)
N3CCW p 94, Aug 88
Ham bands under siege (Backscatter)
N1ACH p 4, Oct 88
Ham Radio techniques
W6SAI p 58, Sep 84
p 67, Jan 86
p 65, Feb 86
p 63, Mar 86
p 42, Apr 86
p 39, May 86
p 30, Jun 86
p 66, Jul 86
p 43, Aug 86
p 42, Sep 86
p 38, Oct 86
p 73, Nov 86
p 59, Dec 86
Ham Radio techniques: BY0AA revisited
W6SAI p 53, Aug 87
Ham Radio techniques: a new country for you
W6SAI p 41, Nov 87
Ham Radio techniques: the joys of TVI or, were you on the air last night?
W6SAI p 70, Aug 88
Ham Radio techniques: The radio boys in the Pacific, or, working DX for Uncle Sam
W6SAI p 26, Nov 88
INUS system (comment)
XE1MD p 9, Jan 88
Legal usefulness of Amateur Radio (comment)
WA7AQN p 9, Aug 88
Locator field list
SM5AGM p 74, Jul 87
Locator field list
SM5AGM p 89, Oct 87
Market survey of amateurs a good idea (comment)
W1FB p 9, p 94 Aug 88
More information needed (comment)
W3QQM p 9, Sept 88
Operating etiquette (letter)
W9MKV p 12, Jul 84
Potential danger (Backscatter)
N1ACH p 4, Nov 88
Re-discovering ham radio (comment)
KC1JG p 9, Aug 88
Service not hobby (letter)
W5VSR p 8, Aug, 85
Comments, KA1YE p 11, Jan 84
TOM remembered (letter)
W1ESN p 11, Jan 84
Comments, K4KI p 11, Jan 84
VHF/UHF world: operating a VHF/UHF micro-wave station
W1JR p 38, Jul 87
Short circuit p 97, Oct 87
VHF/UHF World: Loose ends
W1JR p 53, Sept 86
Volunteer examiners: keep standards high (letter)
K6WX p 12, May 84

OSCILLATORS

Audio oscillator to pulse generator conversion (HN)
W0DLQ p 50, Oct 84
Better frequency stability for the Drake TR7
HB9ABO p 21, Aug 87
Direct synthesis VFO
W7SX p 10, Sept 88
Frequency synthesis by VXO harmonic selection
W3MT p 12, Feb 84
Frequency synthesis up to 2 GHz
WA6DYW p 33, Apr 88
High-stability BFO for receiver applications
K1ZJH p 28, Jun 85
Local oscillators, high stability for microwave receivers and other applications
WB3JZO p 29, Nov 85
Low-noise phase-locked UHF VFO part 1: the noise problem
WA9HUV p 33, Jul 86
Short circuit: Low-noise UHF VFO
WA9HUV p 9, Dec 86
Low-noise phase-locked UHF VCO part 2: construction and testing
WA9HUV p 25, Aug 86
Oscillator, voltage controlled, uses ceramic resonators
K2BLA p 18, Jun 85
Short Circuit p 27, Aug 85
PL tone generator, a programmable
WB0VSZ p 51, Apr 84
Short circuit p 125, May 84
Practically speaking: drift and shift
K4IPV p 75, Jan 88
Universal oscillator circuit
VE6RF p 38, Apr 86
VCO, 1800-2600 MHz
W0DTV p 21, Jul 85
Wideband VCO design
WA4MGX p 49, Jul 84

PACKET

Amateur packet radio networking and protocols, part 1
KR3T p 33, Feb 88
Amateur packet radio networking and protocols, part 2
KR3T p 56, Mar 88
Amateur packet radio networking and protocols, part 3
KR3T p 41, Apr 88
C-64 and GLB PK-1 interface circui
W2EHD p 87, Mar 87
Comments: packet board update p 6, Jan 87
Elmer's notebook: packet radio
W1SL p 100, Oct 87
Exploring packet radio with KISS
WA8BXN p 9, Oct 88
Formatted display of packet using KISS
WA8BXN p 51, Dec 88
4800 baud modem for VHF/UHF packet radio
VE3DNL,VE3DNM,VE3DVV & VE3LNY p 10, Aug 88
Packetimer for the PK-1
W2EHD/exW8KGN p 93, Mar 87
Packet radio conference bridge
WD5HJP p 24, Apr 87
Packet radio PSK modem for
JAS-1/F0-12
G3RUH p 8, Feb 87
RAM drive for packet radio
AD1B p 44, Dec 87
TEXNET packet-switching network-pt 1 system definition and design
WB5PUC & N5EG p 29, Mar 87
TEXNET packet-switching network-pt 2 hardware design
WB5PUC & N5EG p29, Apr 87
TEXNET packet-switching network-pt 3 software overview
WB5PUC & N5EG p53, Jun 87
Using macros with packet (HN)
AD1B p 82, Oct 88

POWER SUPPLIES

An easy-to-build NiCd pulse charger (weekender)
AG6K p 18, Sept 88
Battery-backed master power system
K9ES p 17, Jan 88
Battery charger, NiCd, constant current, a pulsed
K2MWU p 67, Aug 85
Battery storage (comment)
W5JHJ p 6, May 88
Get the most from your NiCds (Weekender)
K3OF p 88, Dec 88
Low-voltage power supplies, designing
W4MLE p 46, Mar 85
Short Circuit p 121, May 85
Precision high-voltage dc regulator
AG6K p 75, Aug 88
Power supply, six-output
Martin, Vaughn D p 12, Oct 84
Power supply, switching high-voltage
W5FG p 48, Apr 84
Practically speaking: bench power supply
K4IPV p 55, Mar 86
Practically speaking: battery problems pt 1
K4IPV p 62, July 87
Practically speaking: battery problems pt 2
K4IPV p 73, Aug 87
Pulse width modulated dc-to-dc converters
W3CZ p 65, Oct 87
Regulated screen grid power supply, A
AG6K p 51, Jun 86
Storing lead-acid batteries (comment)
N5OP p 9, Sept 88
Batteries on concrete (comment)
N5OP p 101, Sept 88
Temperature control, automatic
WB5IRI p 75, Jun 85
The Guerri report: RF power supplies achieve high efficiency
W6MGI p 157, Sep 85
Transformers, wind your own inexpensively
W4GDW p 96, Jun 85

PROPAGATION

Achieve polarization diversity through variable power splitting
W3NGJ p 10, Feb 86
DX forecaster
p 83, Jan 84
p 79, Feb 84
p 93, Mar 84
p 93, Apr 84
p 119, May 84
p 109, Jun 84
p 103, Jul 84
p 63, Aug 84
p 79, Sep 84
p 100, Oct 84
p 92, Nov 84
p 63, Dec 84
p 94, Jan 85
p 75, Feb 85
Short circuit p 117, Jun 85
p 120, Mar 85
p 84, Apr 85
p 79, May 85
p 102, Jun 85
p 100, Jul 85
p 100, Aug 85
p 122, Sep 85
p 105, Oct 85
p 92, Nov 85
p 112, Jan 86
p 78, Feb 86
p 97, Mar 86
p 99, Apr 86
p 118, May 86
p 101, Jun 86
p 91, Jul 86
p 90, Aug 86
p 98, Sep 86
p 92, Oct 86
p 84, Nov 86
Short circuit: HORANT program,
p 92, Oct 86
p 9, Nov 86
p 84, Dec 86
DX forecaster: Winter anomalous absorption
K0RYW p 101, Dec 86
DX forecaster: DX propagation
K0RYW p 108, Jan 87
Comment: HORANT for CP/M
K4GIO p 6, Feb 87
DX forecaster: more DX propagation tips
p 88, Feb 87
DX forecaster: equinox problems
p 106, Mar 87
DX forecaster: a spring DX solution
p 97, Apr 87
DX forecaster: 1986 propagation review
p 105, May 87
DX forecaster: sporadic-E season
p 66, Jun 87
DX forecaster: summer thunderstorm noise
p78, Jul 87
DX forecaster: summertime DX
p 82, Aug 87
DX forecaster: more sporadic-E
p 85, Sep 87
DX forecaster: equinox season DX
K0RYW p 85, Oct 87
DX forecaster: winter DX
K0RYW p 57, Nov 87
DX forecaster: dxing via the winter anomaly
K0RYW p 91, Oct 87
Comments: low band DXing
W0SII p 6, Apr 87
Dx forecaster: solar cycle update
K0RYW p 96, Jan 88
DX forecaster: transequatorial DX update
K0RYW p 90, Feb 88
DX forecaster: the ultimate antipode DX
K0RYW p 78, Mar 88
DX forecaster: DX signal quality
K0RYW p 80, Apr 88
DX forecaster: 1987 propagation summary
K0RYW p 92, May 88
DX forecaster: sporadic E season-1988
K0RYW p 88, Jun 88
DX forecaster: summer thunderstorm noise
K0RYW p 83, Jul 88
DX forecaster: summer signal levels
K0RYW p 88, Aug 88
DX forecaster: high sunspot propagation problems
K0RYW p 104, Sept 88
DX forecaster: high sunspot propagation problems-part 2
K0RYW p 96, Oct 88
DX forecaster: Winter DX season
K0RYW p 108, Nov 88
DX forecaster: Winter DX anomolies
K0RYW p 110, Dec 88
Dxing by computer
NS6N and Buchanan, Walter
p 81, Aug 84
Elmer's notebook: propagation basics
W1SL p 81, Aug 88
EME link calculator program
KE6ZE p 9, Feb 86
Comments, KC8OH p 70, Apr 86
Grayline propagation, fundamentals of
KR7L p 77, Aug 84
Ham Radio techniques: Dx is getting better and better! Here's why!
W6SAI p 28, Apr 88
Ham Radio techniques: On our way up!
W6SAI p 26, Sept 88
Ham Radio techniques: New Zealand, Maui, and the solar cycle
W6SAI p 22, Dec 88
HF ground wave propagation
WA9GFR p 81, May 86
How to plot great circles on your favorite map
W4BW p 81, Aug 86
L-band ground wave propagation program
WA9GFR and Joseph R Hennel
p 103, Jan 86
Comment, WA9GFR p 9, Apr 86
Moon coordinates, determining basic
W2WD p 38, Jan 85
Moon-tracking by computer
K6WX p 38, Mar 84
New band propagation
KK2XJM (W4MB) p 12, Jan 83
Pathfinder—part two
K3FR p 47, Oct 88
Radio astronomy and the search for extra terrestrial intelligence
WB3JZO p 10, Mar 85
Return to the 360-degree propagation prediction
N4UH p 41, Oct 87
Russian Woodpecker, the: a continuing nuisance
KR7L p 37, Nov 84
Solar activity and the earth's magnetosphere
KR7L p 8, Aug 87
Solar outages, predicting
VE7ABK p 75, Mar 85
Sporadic E and 50-MHz transatlantic propagation during 1987
G3NAQ p 10, Jul 88
360-degree MINIMUF propagation prediction
N4UH p 25, Feb 87
VHF meteor scatter communications
AI7J p 69, Feb 84
VHF/UHF world: improving meteor scatter communications
W1JR p 82, Jun 84
VHF/UHF world: the VHF/UHF Primer, an introduction to propagation
W1JR p 14, Jul 84
VHF/UHF world
W1JR p 45, Sep 84
VHF/UHF World: propagation update
W1JR p 86, Jul 85
VHF/UHF World
W1JR p 85, Dec 85
VHF/UHF world: meteor scatter communications
W1JR p 68, Jun 86
Short circuit p 87, Jul 86
VHF/UHF world: μW and mm-wave propagation: part 2
W1JR p 69, Aug 86
VHF/UHF world: propagation update-part 2
W1JR p 39, Jun 88
VHF/UHF world: propagation update-part 3
W1JR p 38, Jul 88

RECEIVERS AND CONVERTERS

general

Cascaded stages, IMD and intercept points of
W3IMG p 28, Nov 84
CB to 10-meter conversions, scanner
W2FMY, KB2GA p 98, Nov 85
Compact 75-meter monoband transceiver
K1BQT p 13, Nov 85
Short circuit p 66, Jan 86
Digital frequency readout using the Commodore 64
W3NNL p 83, Nov 85
Elmer's notebook: receiver buzzwords
W1SL p 100, Nov 87
Extending receive coverage for the IC-02 and IC-04
WB6GTM p 77, Jul 86
External product detector improves receiver performance
W6GB p 107, Nov 85
Frequency calibration using 60 kHz
WWVB
W4ZPS p 45, Mar 88
Ham radio techniques: "white noise" technology bites back
W6SAI p 55, Jan 87
Ham radio techniques: "white noise" revisited
W6SAI p 79, Oct 87
High dynamic range mixing with the Si 8901
KB6QJ p 11, Mar 88
High-stability BFO for receiver applications
K1ZJH p 28, Jun 85
Mixer frequencies, graphical selection
W2HVN p 41, Jun 85
Noise discriminator, a pulsewidth
W6NRW p 23, Nov 84
Noise, understanding and handling
DJ2LR p 10, Nov 86
Preamp at work, Quiet!
N6TX p 14, Nov 84
Receiver input temperature (letter)
WA6JTD p 13, Apr 85
Receiver tuning mechanism selection
PY2PEIC p 31, Nov 86
Receiver, 10 through 80-meter home brew
N1BFV p 40, Nov 85
S-meter, a calibrated
W7SX p 23, Jan 86
Short circuit p 45, Apr 86
Spectrum analyzer, a handheld optical
WA4WDL p 23, Apr 84
Ten-Tec Argosy, Upgrade
WB3JZO p 38, Nov 86
True frequency digital readout for the HW-101
NU4F p 8, Jan 87
Short circuit p 41, Aug 87
TS-930S headset audio, increase undistorted (HN)
W6FR p 128, Oct 85
VHF/UHF world high dynamic range receivers
W1JR p 97, Nov 84
Short circuit p 103, Jan 85
VHF/UHF world: broadband amplifiers in receiver design
W1JR p 91, Nov 86
VHF/UHF World: low-noise receiver update part 1
W1JR p 77, Nov 87

hf

Better frequency stability for the Drake TR7
HB9ABO p 21, Aug 87
CAT control system for the Yaesu FT-757CX
SM6CPI p 26, Nov 87
Comments KA0GPE p 10, Mar 84
Compact 20-meter CW receiver, A
K1BQT p 8, Jun 87
Short circuit p 6, Jul 87
Short circuit p 81, Sep 87
Designing a state-of-the-art receiver
KA2WEU/DJ2LR p 11g, Nov 87
Digital HF radio: a sampling of techniques
KA2WEU/DJ2LR p 19, Apr 85
Short circuit p 121, May 85
Frequency calibration using 60 kHz
WWVB
W4ZPS p 45, Mar 88
HF superhet, 20-meter
N3ECZ p 65, Nov 86
High dynamic range mixing with the Si 8901
KB6QJ p 11, Mar 88
High-frequency receiver performance
G4OBU p 33, Feb 84
Pepperdyne receiver
W6QIF p 33, Nov 88
Receiver, Pocket-portable SSB
WB6BIH p 55, Nov 86
Receiver sweep alignment system
WB6BIH p 124, Nov 84
Shortwave receiver, portable
PY2PE1C p 67, Apr 84
Simple direct conversion receiver
WA3ENK p 9, Dec 88
Simple receivers from complex ICs
W6VEH p 10, Nov 88
Solid-state 75A-4 receiver
KF7M p 67, Nov 88
Superhet coilset, design with a microcomputer
Sterrenburg, FAS p 113, Nov 84
SW receiver, a double conversion portable
PY2PE1C p 48, Nov 84
Thumbwheel frequency selector for the Yaesu FT-757-GX
KA9SNF p 33, Nov 87
Transceivers, quasi-bilateral if for
K1ZJH p 75, Dec 84
Two-band receiver, extending the modular
WA3TFS p 57, Nov 84
Comments WA3TFS p 8, Sep 84
Tomorrow's receivers: what will the next 20 years bring
W7SX p 8, Nov 87
80-meter receiver, simple
WB2EAV p 25, Nov 86

vhf

Extending receive coverage for the IC-02 and IC-04
WB6GTM p 77, Jul 86
Modular transmit and receive converters for 902 MHz
N6JH p 17, Mar 87
VHF/UHF world: VHF/UHF receivers
W1JR p 42, Mar 84
VHF/UHF World: low noise receiver update-part 1
W1JR p 77, Nov 87
VHF/UHF World: low noise receiver update-part 2
W1JR p 72, Dec 87

RTTY

New MSO for RTTY (letter)
N2EO p 12, Jul 84
Short circuit p 10, Feb 84
RTTY oscilloscope input using line transformers (HN)
W6XM p 87, Sep 84
Run RTTY on your Timex
NU4V p 110, Apr 85
Run RTTY on your VIC-20
W5TRS p 120, Apr 85
Timex/Sinclair newsletter (letter)
AD1B p 12, Jul 84
Tuning indicator for RTTY and packet radio
W0HZR p 65, Sept 88
VIC-20 printer (HN)
W2QLI p 88, Sep 84
Short circuit p 145, Mar 85

SATELLITES

Demodulator, telemetry, PSK, for OSCAR 10
G3RUH p 50, Apr 85
Elevation indicator, inexpensive
W5JTL p 67, Jun 85
First HT-to-HT QSO via OSCAR 10
WA2LQQ p 32, Sep 84
G.O.E.S. reception: a simple approach
WA4WDL p 46, Jan 84
Introducing satellite communications
G3ZCZ p10, Apr 86
Moon-tracking by computer
K6WX p 38, Mar 84
Packet radio PSK modem for JAS-1/FO-12
G3RUH p 8, Feb 87
Satellite tracker, digitally-controlled
KA8OBL p 102, Sep 85
Signals from space, receiving
K8UR p 67, Nov 84
The Guerri report: super speed semiconductor
W6MGI p109, Oct 86
The Guerri report: communication satellites
W6MGI p 108, Jun 86
Comments: update on ACSSB level-one adapter, project OSCAR (Oct 86)
WB6JNN p9, Nov 86
Work OSCAR 10 with your HT
WA2LQQ p 29, Sep 84

SEMICONDUCTORS

Cooling semiconductors part 1: designing and using heatsinks
Martin, Vaughn D p 33, Jul 84
Cooling semiconductors part 2: blowers and fans
Martin, Vaughn D p 52, Aug 84
High dynamic range mixing with the Si 8901
KB6QJ p 11, Mar 88
Practically speaking: solid state rectifiers
K4IPV p 51, Aug 86
Practically speaking: substituting transistors-part 1
K4IPV p 92, Sep 86
Practically speaking: substituting transistors-part 2
K4IPV p 66, Oct 86
Practically speaking: non-ideal linear IC amplifiers
typical problems and how to solve them
K4IPV p 72, Jul 88
The Guerri report: super speed semiconductors
W6MGI p 109, Oct 86
Transistor biasing, back to basics
WD4C p 91, Dec 84
VHF/UHF world: the ubiquitous diode
W1JR p 51, Feb 87
VHF/UHF WORLD: The ubiquitous diode part 2
W1JR p 55, Mar 87

SINGLE SIDEBAND

ACSSB: a level-one adapter
WB6JNN p 10, Oct 86
Adjusting SSB amplifiers
AG6K p 33, Sep 85
Better sounding SSB
AG6K p 58, Feb 84
Comments W2OZH p 13, Jun 84
Development of Amateur SSB: a brief history
K4KJ p 12, Sep 84
Comments, AG4R p 8, Dec 84
Elmer's notebook: power measurements
W1SL p 100, Jan 88
Elmer's notebook: SSB basics-generating the signal
W1SL p 117, Nov 88
Elmer's notebook: SSB basics-receiving the signal
W1SL p 117, Dec 88
Ham radio techniques
W6SAI p 106, Oct 84
Linear amplifier, HF solid-state kilowatt, mobile
WA7SPR p 67, Feb 85
Weaver modulation, 2-meter transmitter
N1COX p 12, Jul 85

SOFTWARE

BASIC program analyzes simple ladder networks
W3NQN p 32, Aug 87
Short circuit p 97, Oct 87
Design a no-tune amplifier with your personal computer
W7DHD p8, Sep 87
Design program for the grounded-grid 3-500Z
W7DHD p 8, Jun 88
EME link calculator program
KE6ZE p 70, Feb 86
Comments, KC8OH p9, Apr 86
Gel on SSTV-with the C-64
I2CAB and I2AED, edited by K9EI p 43, Oct 86
Great circle computations using LOTUS 1-2-3
AD1B p 31, Sept 88
L-band ground wave propagation program
WA9GRF and Joseph R. Hennel p 103, Jan 86
Morse code teaching tools for the C-64 and 128
KB8CS p 35, Jan 88
Pathfinder: improved MINIMUF program
K3FR p 26, May 88
Pathfinder-part 2
K3FR p 47, Oct 88
Using macros with packet
AD1B p 82, Oct 88
Using spreadsheet programs for amateur radio projects
AD1B p 95, Dec 86

TELEVISION

A tour through an NTSC TV station-part 1 (historical aspects)
KL7AJ p 57, Dec 87
Get on SSTV with the C-64
K9EI p 43, Oct 86
Short Circuit p 97, Oct 87
Remarks on television series (comment)
KB9FO p 6, May 88
Technology of commercial television-part 2: hardware
KL7AJ p 54, Jan 88

TRANSMITTERS AND POWER SUPPLIES

general

Adjusting SSB amplifiers
AG6K p 33, Sep 85
Aural vco provides relative metering
K1ZJH p 97, Jan 87
Design a no-tune amplifier with your personal computer
W7DHD p8, Sep 87
Grounded-grid amplifier parasitics
AG6K p 31, Apr 86
Comment, NJ0G p 9, Jul 86
Comment, W2YW p 6, Jul 86
Ham radio techniques: super cathode driven amplifier
W6SAI p 73, Nov 86
Ham radio techniques: "white noise" technology bites back
W6SAI p 55, Jan 87
Ham radio techniques: "white noise" revisited
W6SAI p 79, Oct 87
MC1496, improved carrier suppression (HN)
K1ZJH p 78, Apr 85
Short circuit p 74, Jul 85
MMIC multiplier chains for the 902 MHz band
N6JH p 72, Feb 87
Short circuit p 64, May 87
Practically speaking: noise, signals and amplifiers
K4IPV p 77, Feb 88
RF switching, high power with pin diodes
KN8Z p 82, Jan 85
Three-tube 4CX250B linear amplifier
YU1AW p 63, Apr 87
True frequency digital readout for the HW-101
NU4F p 6, Jan 87
Short circuit p 41, Aug 87

hf

Amplifier, 3CX1200A7 10 to 80 meter
K8RA p 75, Aug 85
Better frequency stability for the Drake TR7
HB9ABO p 21, Aug 87

CAT control system for the Yaesu FT-757GX
SM6CPI p 26, Nov 87
Compact 75-meter monoband transceiver
K1BQT p 13, Nov 85
Convert a $25 CB HT for 6 meters
K1ZJH p 79, Aug 87
Design an amplifier around the 3CX1200A7
W7DHD p 33, Dec 87
Ham notebook:curing FT-1012D key clicks
N5RM p 74, Feb 88
Ham radio techniques: 160-meter equipment
W6SAI p 77, Mar 87
High dynamic range mixing with the Si 8901
KB7QJ p 11, Mar 88
Linear amplifier, HF, solid-state kilowatt, mobile
WA7SPR p 67, Feb 85
Thumbwheel frequency selector for the Yaesu FT-757GC
KA9SNF p 33, Nov 87
TS-440 Interface for keying linears with high voltage biasing (HN)
W6WTU p 98, Nov 88
Vacuum tube amplifier, design a toroidal tank circuit for
W6YUY p 29, Aug 85
Short circuit p 66, Jan 86

TROUBLE-SHOOTING

GLA-1000 amplifier, stop blowing finals
G4CFY, G3ROG p 59, Aug 85
Grounded-grid amplifier parasitics
AG6K p 31, Apr 86
Comment, NJ0G p 9, Jul 86
Comment, W2YW p 6, Jul 86
Practically speaking: coax velocity factor
K4IPV p 78, Nov 86
Practically speaking: using the multimeter
K4IPV p 43, Jul 86
Practically speaking: using the right multimeter
K4IPV p 95, Jun 86
Practically speaking
K4IPV p 35, Feb 86
Practically speaking
K4IPV p 59, Jan 86
TVI problem, solving a difficult (HN)
W2YW p 152, Sep 85

VHF AND UHF

general

ATV power amplifier, fast-scan
WB0ZJP p 67, Mar 85
Audio to microwave amplifier, build your own
Gruchalla, Michael p 12, Mar 84
Bandpass filter design, interdigital, computer-aided
N6JH, Monemzadeh p 12, Jan 85
Short circuit p 117, Jun 85
Bicycle mobile
NH6N p 38, Sept 88
Converting mobile microphones for hand-held VHF transceiver
KD8KZ and WB3JCC p 79, Mar 86
Designing a microwave amplifier
Domanski, S p 30, Sep 87
Dual wattmeter, 50-500 Hz
WB4EHS p 67, Jul 85
Duplexer, six cavity, home-brewed
K9EYY p 12, Feb 85
EME link calculator program
KE6ZE p 70, Feb 86
Elevation indicator, inexpensive
W5JTL p 67, Jun 85
Elmer's notebook: 220 MHz
W1SL p91, Aug 87
Elmer's notebook: 1200 MHz band
W1SL p 113, Dec 87
Get on 6 meters the inexpensive way
KB1KJ p 91, Mar 85
GOES reception: a simple approach
WA4WDL p 46, Jan 84
L-band ground wave propagation program
WA9GFR and Joseph R Hennel p 103, Jan 86
Local oscillators, high stability for microwave receivers and other applications
WB3JZO p 29, Nov 85
Measuring noise figure
K2BLA p 26, Jan 84
Micros and VHF beacons transmit messages automatically
K9EI p 51, Jul 85
Microstrip impedance program
K8UR p 84, Dec 84
MMIC multiplier chains for the 902 MHz band
N6JH p 72, Feb 87
Short circuit p 64, May 87
Modular transmit and receive converters for 902 MHz
N6JH p 17, Mar 87
Monolithic RF amplifiers
N6JH p 22, Mar 86
Moon coordinates, determining basic
W2WD p 38, Jan 85
Moon-tracking by computer
K6WX p 38, Mar 84
Novice enhancement and the 220 MHz band, Reflections:
W9JUV p 4, Apr 87
Power dividers, extended/expanded
W5JTL p 73, Oct 84
Power FETs: trend for VHF amplifiers
W7PUA and Peters, Dex DL4VJ p 12, Jan 84
Practically speaking: parametric amplifiers
K4IPV p 65, Mar 88
Preamp at work, Quiet!
N6TX p 14, Nov 84
Remote base/simplex phone patch controller
AA4NX & KK4LA p 54, Aug 88
RF transmission cable, microwave applications
K3HW p 106, May 85
Silverplating, safe, sensible
K9EYY p 29, Feb 85
Simple VHF/UHF multiple quarter-wave filters
WA3EWT p 37, Sep 87
Sporadic E and 50-MHz transatlantic propagation during 1987
G3NAQ p 10, Jul 88
The Guerri report: signal processing
W6MGI p 156, Dec 84
The Guerri report: mm waves, part 1
W6MGI p 109, Feb 86
The Guerri report: mm waves, part 2
W6MGI p 117, Mar 86
The Guerri report: fiber optics
W6MGI p 141, May 86
Trade off power for antenna gain at VHF
WA9GFR, Hennel p 32, Jul 85
Comment, WA9GFR p 9, Apr 86
23 GHz prescaler
N6JH p 21, Jan 87
UHF antenna tower, low-cost
KA6GVY p 30, Oct 84
VHF amplifiers, carrier-operated relay
WB3JCC, KD8KZ p 45, Apr 85
VHF meteor scatter communications
AI7J p 69, Feb 84
VHF noise bridge
OE2APM/AA3K p 10, Jul 86
VHF signal generation, harmonic mixer
K1ZJH p 40, Mar 85
Short circuit p 121, May 85
VHF/UHF world: the VHFUHF challenge
W1JR p 42, Jan 87 VHF/UHF world: improving meteor scatter communications
W1JR p 82, Jun 84
VHF/UHF world: microwave bands
W1JR p 44, Jan 86
VHF/UHF world: the VHF/UHF primer, an introduction to propagation
W1JR p 14, Jul 84
VHF/UHF world: the VHF/UHF Primer, an introduction to filters
W1JR p 112, Aug 84
VHF/UHF world
W1JR p 45, Sep 84
VHF/UHF world
W1JR p 55, Oct 84
VHF/UHF world low-noise GaAs FET technology
W1JR p 99, Dec 84
VHF/UHF world: high power amplifiers: part 1
W1JR p 97, Jan 85
VHF/UHF world: high power amplifiers: part 2
W1JR p 38, Feb 85
VHF/UHF world: keeping VHF/UHFers up-to-date
W1JR p 126, Mar 85
VHF/UHF world: protecting equipment
W1JR p 83, Jun 85
VHF/UHF world: propagation update
W1JR p 86, Jul 85
VHF/UHF world: designing and building loop Yagis
W1JR p 56, Sep 85
VHF/UHF world transmission lines
W1JR p 83, Oct 85
Comment, W9ICZ p 9, Apr 86
VHF/UHF world
W1JR p 54, Nov 85
VHF/UHF world
W1JR p 85, Dec 85
VHF/UHF world: μw and mm-wave propagation, part 2
W1JR p 69, Aug 86
VHF/UHF world: meteor scatter communications
W1JR p 68, Jun 86
Short circuit p 87, Jul 86
VHF/UHF world: microwave bands
W1JR p 44, Jan 86
VHF/UHF world: 33 cm-our newest band
W1JR p 83, Apr 86
Short circuit (p 87, July 86) p 9, Aug 86
VHF/UHF world: rf connectors, part 1
W1JR p 77, Sep 86
VHF/UHF world: rf connectors, part 2
W1JR p 59, Oct 86
VHF/UHF world: microwave and millimeter-wave update
W1JR p 63, Jan 87
VHF/UHF world: 33 cm update
W1JR p 74, Apr 87
Short circuit p 81, Sep 87
VHF/UHF world: microwave portable operation
W1JR p 75, Jun 87
Short circuit p 81, Sep 87
VHF/UHF world: minimum requirements for 2-meter EME-pt 2
W1JR p 65, Sep 87
VHF/UHF world: Operating a VHF/UHF microwave station
W1JR p 38, Jul 87
Short circuit p 81, Sep 87
Short circuit p 97, Oct 87
VHF/UHF world: minimum requirements for 2-meter EME-pt 1
W1JR p39, Aug 87
Comments, W7WRQ p 9, Dec 87
VHF/UHF World: impedance matching techniques
W1JR p 27, Oct 87
VHF/UHF world: loose ends
W1JR p 82, Feb 88
VHF/VHF world: power splitters and summers
W1JR p 80, May 88
VHF/UHF world:: IMD and splatter
W1JR p 71, Oct 88
23 GHz prescaler
N6JH p 21, Jan 87

antennas

Antenna insulators, PTFE VHF
W5JTL p 98, Oct 85
Cheap and dirty 6-meter beam
W5UOJ p 56, Jul 88
Convert an inexpensive CB mag-mount antenna into a superb 2-meter whip
K7DBA p 52, Oct 86
Colagi antenna, The
VE3BFM p 61, May 86
Computer-aided design of long VHF Yagi antennas
VK4ZF p 28, May 86
Cylindrical feedhorns revisited
WA9HU p 20, Feb 86
Direction-finding tool, the fox box
K1ZJH p 25, Oct 85
Ham notebook: 2-meter halo antenna
NR5A p 63, May 87
High-performance Yagis for 432 MHz
K1FO p 8, Jul 87
Comments: KLM balun
Scott, W p 6, Sep 87
Short circuit p 97, Oct 87
Long 2-meter collinears a simple way to achieve gain (HN)
WB3AYW p 95, May 86
Open-wire line for 2-meters
N4UH p 94, Jan 87
VHF/UHF world: VHFUHF antennas and antenna systems
W1JR p 46, Feb 84
Short circuit p 54, Jan 86
VHF/UHF world: stacking antennas, part 1
W1JR p 129, Apr 85
VHF/UHF world: stacking antennas, part 2
W1JR p 95, May 85
VHF/UHF world
W1JR p 85, Dec 85
VHF Yagi CAD on the C-64
W4PFZ p 70, Sep 86
VHF/UHF world: Yagi facts and fallacies
W1JR p 103, May 86
VHF/UHF world: reflector antennas, part 1
W1JR p 51, Feb 86
Short circuit p 45, Apr 86
VHF/UHF world: reflector antennas, part 2
W1JR p 68, Mar 86
Yagi, a high-gain 70-cm
W1JR p 75, Dec 86
Short circuit P 68, Feb 87
VHF/UHF world: Optimized 2- and 6-meter Yagi
W1JR p92, May 87
Short circuit p 26, Jun 87
Short circuit p 49, Jul 87
Short circuit p 41, Aug 87
Short circuit p 81 Sep 87
Yagi trigon reflector, Optimizing
WB3BGU p 84, Jan 86
2-meter beam, portable
KB5QJ p 113, Oct 85
6-meter kilowatt amplifier
KX0O p 50, Jul 86

receivers and converters

Local oscillators, high stability for microwave receivers and other applications
WB3JZO p 29, Nov 85
TR-2500/2600 2-channel programming (HN)
K9MLD p 128, Oct 85
VHF/UHF world: VHF/UHF receivers
W1JR p 42, Mar 84
VHF/UHF world low-noise GaAs FET technology
W1JR p 99, Dec 84
VHF/UHF world
W1JR p 54, Nov 85
VHF/UHF World. low noise update, part 2
W1JR p 72, Dec 87
Yaesu's latest VHF/UHF receiver, add general coverage
W6MGI p 67, Oct 85
Short circuit p 97, Oct 87
2-meter monitor
WA3ENK p 64, Jul 88
1296-MHz low noise amplifier (Weekender)
WA9HUV p 60, Nov 88

transmitters

Amplifier, 432-MHz, 1500-watt
W2GN p 40, Jul 85
Low-noise phase-locked UHF VCO part 1: the noise problem
WA9HUV p 33, Jul 86
Short circuit p 9, Dec 86
Low-noise phase-locked UHF VCO part 2: construction and testing
WA9HUV p 25, Aug 86
Temperature control, automatic
WB5IRI p 75, Jun 85
TR-2500/2600 2-channel programming (HN)
K9MLD p 128, Oct 85
VCO, 1800-2600 MHz
W0DTV p 21, Jul 85
VHF/UHF world: medium power amplifiers
W1JR p 39, Aug 85
VHF/UHF world: VHF/UHF exciters
W1JR p 84, Apr 84
Short circuit p 60, Oct 84
Weaver modulation, 2-meter transmitter
N1COX p 12, Jul 85
X-band beacons
WA6EJO p 29, Jan 87

microwave techniques

Designing a station for the microwave bands: part 1
N6GN p 41, Feb 88
Designing a station for the microwave bands: part 2
N6GN p 19 Jun 88
Short circuit: p 35, Oct 88
Designing a station for the microwave bands: part 3
N6GN p 17, Oct 88
Radial line stub design
N1BEP p 65, Feb 88
VHF/UHF world: microwave components and terminology-part 1
W1JR p 71, Mar 88
VHF/UHF world: microwave components and terminology-part 2
W1JR p 67, Apr 88



(continued from page 70)

For more information contact Communications Specialists, Inc., 426 West Taft Avenue, Orange, California 92665-4296.

Circle #306 on Reader Service Card.

900-MHz phase lock loop synthesizer

RF PROTOTYPE SYSTEMS adds the PLL1 to its QUICK BOARD product line. The board is the basis for a 900-MHz Phase-lock Loop Synthesizer. Several PLL configurations can be implemented with user selected divide ratios, VCO, loop filter, and associated components to be installed in the PLL1. The PLL1 lets you build a PLL that allows you to optimize parameters, or produce a low cost frequency source.

The design is based on the Motorola MC145152 dual-modulus, parallel-interface synthesizer IC and uses common dividers and op amps. The loop filter is laid out for a standard third order type 2 PLL. Frequencies are programmed with parallel data input provided by on-board dip switches.

The PLL1 includes a circuit board, schematic, assembly drawing, and an application note on how to build a PLL using the PLL1 QUICK BOARD.

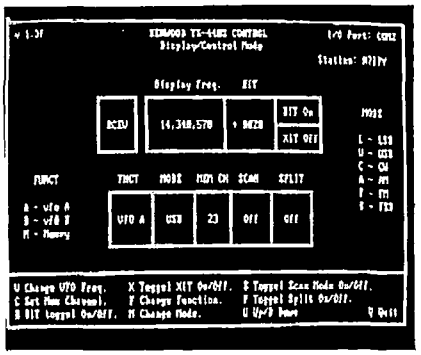
The price in quantities of 1-9 is $95.00.

For more information, please contact RF PROTOTYPE SYSTEMS, (619) 538-6771, 12730 Kestrel Street, San Diego, California 92129.

Circle #307 on Reader Service Card.

Rad-Com Soft-Control

Soft-Control software provides remote access to your radio's functions via a serial link from your PC. Using the radio's built-in command set, the program lets you control the functions of your transceiver from a simple menu. Soft-Control also includes complete maintenance of the radio's memory channels. Memory data can be added, deleted, or edited and then saved to, or restored from disk.



Available immediately for the Kenwood TS-440S and IBM PC or compatible, other radio-computer combinations are expected to be available soon. The program can be purchased directly from Rad-Com and sells for $59.95.

For more information, or to order contact: Rad-Com, P.O. Box 1166, Pleasanton, California 94566.

Circle #308 on Reader Service Card.

4-digit sequence decoder and "QUAD" option

The new model TSDQ 4-digit sequence decoder replaces the TSD decoder. Its features include a DPDT 2-A relay, on board 5-volt regulator, digit valid indicator, and expansion connector. Connections to the board are via a 24-pin card-edge connector, which provides quick disconnect and expansion with the new Model "QUAD" 4-relay expansion card.

The TSDQ operates as a stand-alone 2-4 digit touchtone sequence decoder. Output may be either latching or momentary control of the DPDT relay. All 16 digits are output to the card-edge connector and can be used for single digit commands. The relay turns on when it receives a 4-digit code and turns off when the code is received again. When the QUAD option is plugged in, four DPDT relays may be turned on and off with individual access codes. A master "on" code, followed by the relay number, turns on a relay; a master "off" code, followed by the relay number, turns the relay off. These relay on/off codes can be a total of 3-5 digits long. In addition to the relay outputs there are four transistor outputs to provide LED readouts of the relay states, or act as control voltage for other devices. All output connections are via a 24-pin card-edge connector which uses the same pin numbers for all inputs as the TSDQ card. This allows instant compatibility when the QUAD expansion card is added.

Model "TSDQ" is $79.95 including 24-pin edge connector. Model "QUAD" is $99.95 (requires "TSDQ"). Add $3.00 shipping. California residents add 6 percent.

Additional information can be obtained by contacting, Engineering Consulting, 583 Candlewood Street, Brea, California 92621.

NCG Co. introduces new items

NCG Co. has the following new items available:

•900-MHz mobile antenna. Model no. CMW3-71 is a 5/8-wave × 3-step wide-band antenna. Gain is 7.14 dB, maximum power is 50 watts. Length is 2′7″. Frequency for a 1.5 VSWR is 910-940 MHz, the base has a fold-over design for low garage parking.

•Dual-band UHF/1.2-GHz mobile antenna. The Model CHL-120 is a wide-band low VSWR mobile antenna for the high frequencies. Gain is 2.15 dB for UHF and 5.6 dB for 1.2 GHz. Maximum power is 50 watts, VSWR is 1.8 or less, length is 1′2″. Simulcast operation is possible when used with the CF-413 duplexer.

•CM-900 Mini Meter. Designed for the 900-MHz band, insertion loss is less than 0.2 dB; measurable power is from 0 to 120 watts. SWR is 1.0-5, power range 10/120W accuracy is 0.55±, dimensions are 2.25″W × 2.55″H × 1.1″D.

•CM-300 Mini Meter. Designed for the 200-240 MHz, insertion loss is less than 0.2 dB; measureable power is from 0-60 watts. SWR measurement 1.0-5 to 1. Accuracy is 0.50±, dimensions are 2.25″W × 2.55″H × 1.1″D. The CM-300 is equipped with UHF connectors.



•Low-loss coax mounting kits. The CK-5LX is the 5DQEV + RG188A/u. The CK-5LX is usable from 1 MHz to 1.5 GHz. The CK-3LX is the 3.5DQEV + RG188A/u, The CK-3LX is usable from 1 MHz to 900 MHz. The loss for the coax is: 3.5DQEV at 400 MHz 3.5, at 1000 MHz 5.6 per 100 feet. 5D-QEV at 400 MHz 3.2, at 1000 MHz 5.3.

For further information on any of these items, contact NCG Co. 1275 N. Grove Street, Anaheim, California 92806.

Circle #309 on Reader Service Card.

(continued on page 125)



DX FORECASTER

Garth Stonehocker, KØRYW

Winter DX Anomalies

The winter DX season usually has higher signal strengths and lower thunderstorm noise than the summer, particularly on the lower bands. Both of these conditions increase the signal-to-noise ratio at our receivers, making winter the enhanced DX season. These geophysical conditions occur at this time because the sun's subsolar point (spot on earth directly under the sun) moves down to the Southern Hemisphere. The big thunderstorms are located over the southern land masses, so an added F-region hop is needed to propagate to those of us in the northern mid-to-high latitudes. The amount of signal absorbed is related to the solar zenith angle present at the D-region transmit points on the signal's propagation path. The southern position of the sun lowers this angle and, in turn, lowers the absorption.

The anomally of this ordinarily improved wintertime signal is the five to six day periods of 20 to 40-dB weaker signals (more like summertime) through the mid-to-high latitude paths providing our communication links to European, Asian, and Japanese Amateurs. I've discussed the cause in detail in past December columns; it affects those latitudes in 90 degree increments of longitude. The latitudes directly opposite each other have higher than normal winter signals, and those opposite but on different longitudes have lower than normal winter signals. The areas rotate 30 degrees (two time zones) per day, while decreasing from 65 down to 30 degrees latitude in the five days of rotation.

To take advantage of the decreased absorption that provides strong DX signals on east, west, and transpolar paths, access WWV or the bulletin board to keep track of the daily geomagnetic A value during the winter (mainly January). Continue to keep track after each A value of 15 or higher, until a STRATWARM is given. Then, consult your map or globe to find the 90-degree position between the location given for the STRATWARM and its 180-degree companion. Coordinate your beam bearings and the DX path control points (1200 miles from the QTHs "on" the great circle) with the areas of lower absorption on both ends, or at least one end. If the area isn't right for your DX on that particular day, you can forecast — at 30 degrees of longitude and lower latitude per day — when you can expect good results during the five to six days to come.

Another geophysical winter effect that seems like an anomaly is the higher wintertime maximum usable frequencies (MUFs). True, the D, E, and lower F region have larger electron densities in summer, but the maximum density of the F-region (which usually sets the day's MUF) peaks during the winter instead. This peak isn't as broad (measured by hours of the day) as it is in the summer — it's narrower and higher. You have to be right there when the band opens (on 10 meters, for instance) to catch these few hours. This same effect makes the one-long-hop transequatorial propagation possible in the evenings.

Last-minute forecast

The second and third full weeks of the month should have excellent higher frequency (10 to 30 meter) DX band openings. Expect both long-skip and extra DX transequatorial openings from high MUF build-up during the day and evenings. Some short-skip sporadic E openings might even help your DX. The lower bands should be best the first and fourth weeks. (This includes Christmas weekend for those trying out some new equipment from under the tree!) Low bands are a great way to spend these long nights by the fire with friends.

The Geminids meteor shower, which peaks on December 13th and 14th, will provide the richest and most reliable display of the year, with rates of 60 to 70 per hour. Because optical observations may be difficult or impossible to make during periods of poor December weather, determine the actual numbers by radio reception. A smaller version of the shower will occur on December 22nd. The full moon appears on the 23rd, and lunar perigee happens on the 16th. Winter solstice is on December 21st at 1528 UTC.

Band-by-band summary

Ten, 12, 15, and 20 meters will be open from morning until early evening almost every day to most areas of the world. The openings on the higher of these bands will be shorter and occur closer to local noon. Transequatorial propagation on the higher bands will probably occur toward evening, during times of high solar flux and disturbed geomagnetic field conditions.

DECEMBER

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	4:00	*40*	40	20	15	12*	12	10	15	5:00	*40*	40	20	15	12	10	10	20	6:00	7:00	*40*	40	20	15	15	15	12	30
0100	5:00	20	40	20	15	12	10	10	20	6:00	30	40	20	15	12	10	12	30	7:00	8:00	30	40	20	15	15	20	20	30
0200	6:00	30	40	20	20	12	10	12	20	7:00	30	40	20	20	15	12	15	30	8:00	9:00	30	*40*	20	20	20	20	20	30
0300	7:00	30	*40*	20	20	15	10	15	20	8:00	30	*40*	*20*	20	15	12	20	30	9:00	10:00	30	*40*	*20*	20	20	20	20	30
0400	0:00	30	*40*	*20*	20	15	12	20	30	9:00	30	*40*	*20*	*20*	20	15	20	30	10:00	11:00	30	*40*	*20*	*20*	20	20	20	30
0500	9:00	30	*40*	*20*	*20*	20	12	20	30	10:00	30	*40*	*20*	*20*	20	20	20	30	11:00	12:00	*40*	*40*	*20*	*20*	*20*	20	20	30
0600	10:00	40*	*40*	*20*	*20*	20	15*	20	30	11:00	30	*40*	*20*	*20*	20	20	20	30	12:00	1:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	40
0700	11:00	30	*40*	*20*	*20*	20	15*	20	30	12:00	40	*40*	*20*	*20*	*20*	20	*20*	40	1:00	2:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	40
0800	12:00	30	*40*	*20*	*20*	*20*	15	*20*	30	1:00	40	*40*	*20*	*20*	*20*	20	*20*	40	2:00	3:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	40
0900	1:00	40	40	*20*	*20*	*20*	15	*20*	30	2:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	40	3:00	4:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*40*
1000	2:00	40	*40*	*20*	*20*	*20*	15	*20*	30	3:00	*40*	*40*	*20*	*20*	*20*	*20*	*20*	*40*	4:00	5:00	*40*	30	15	*20*	*20*	*20*	*20*	*40*
1100	3:00	40	*40*	*20*	*20*	*20*	20	*20*	40	4:00	*40*	*40*	15	*20*	*20*	*20*	*20*	*40*	5:00	6:00	20	20	12	15	*20*	*20*	*20*	*40*
1200	4:00	*40*	*40*	15	*20*	*30*	*20*	*20*	*40*	5:00	*40*	20	12	15	*20*	*20*	*20*	*40*	6:00	7:00	20	20	12	15	*20*	*20*	*20*	*40*
1300	5:00	*40*	*40*	12	15	*20*	*20*	*20*	*40*	6:00	20	20	12	15	*20*	*20*	*20*	*40*	7:00	8:00	30	20	12	12	20	20	15	30
1400	6:00	*40*	20	12	15	*20*	*20*	*20*	*40*	7:00	20	20	12	12	20	*20*	20	30	8:00	9:00	30	20	10	12	15	20	15	30
1500	7:00	*40*	20	10	12	15	*20*	20	*40*	8:00	30	20	10	12	15	*20*	20	30	9:00	10:00	30	20	10	12	15	20	15	40
1600	8:00	30	20	10	12	15	*20*	20	*40*	9:00	30	20	10	12	15	20	15	40	10:00	11:00	30	20	10	10	15	20	20	40
1700	9:00	30	20	10	12	15	*20*	20	*40*	10:00	30	20	10	10	15	15	15	*40*	11:00	12:00	30	20	10	10	12	15	*20*	*40*
1800	10:00	40	30	10	10	15	15	20	*40*	11:00	30	30	10	10	12	15	20	*40*	12:00	1:00	30	20	10	10	12	15	20	*40*
1900	11:00	40	30	12	10	12	15	15	*40*	12:00	40	30	10	10	12	15	20	*40*	1:00	2:00	30	30	12	10	12	12	15	*40*
2000	12:00	*40*	30	12	10	12	15	15	20	1:00	40	30	12	10	12	12	15	*40*	2:00	3:00	40	30	12	10	12	10	12	*40*
2100	1:00	*40*	30	15	10	12	12	12	20	2:00	*40*	30	12	10	12	12	12	20	3:00	4:00	*40*	30	15	10	12*	10	12	20
2200	2:00	*40*	30	15	10	12	12	12	20	3:00	*40*	30	15	12	12*	12	12	20	4:00	5:00	*40*	30	20	12	12*	10	10	20
2300	3:00	*40*	30	15	12	12*	12	10	15	4:00	*40*	30	15	12	12	10	10	20	5:00	6:00	*40*	40	20	12	12	12	10	20
		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

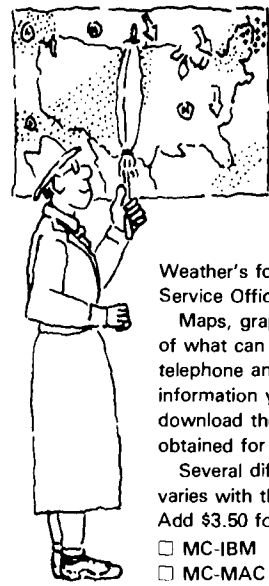
*Look at next higher band for possible openings.

You'll find 30 and 40 meters useful almost 24 hours a day. Daytime conditions will resemble those on 20 meters. Skip distances and signal strengths may decrease during midday on days that coincide with these higher solar flux values. Expect good nighttime DX, except after days of high MUF conditions and during geomagnetic disturbances. Look for DX from unusual places on eastern, northern, and western paths during this time. The usable distance is expected to be somewhat less than on 20 in the daytime and greater than on 80 at night.

Eighty and 160 meters will exhibit short-skip propagation during daylight hours and lengthen for DX at dusk. These bands follow the darkness regions opening to the east just before your sunset, swinging more to the south around midnight, and ending up in the Pacific areas an hour or so before dawn.

Article K

HAM RADIO



WEATHER SOFTWARE

ACCU-WEATHER FORECASTER is a menu driven program that allows the user to tap into Accu-Weather's extensive computerized database. In addition to Accu-Weather's forecasts, you can get hourly updates from National Weather Service Offices nationwide.

Maps, graphs, pictures, charts, and narrative descriptions are just part of what can be downloaded to your MS-DOS computer. To save telephone and hook-up charges, tell your computer first exactly what information you want. Then call ACCU-WEATHER; the computer will download the files you want and save them to disk. Information can be obtained for the entire United States or a specific geographical region.

Several different services are available from ACCU-WEATHER. Price varies with the service and time of day that the computer is accessed. Add $3.50 for shipping and handling.

☐ MC-IBM $89.95
☐ MC-MAC $89.95

Please add $3.50 for shipping and handling

HAM RADIO BOOKSTORE

GREENVILLE, NH 03048 *603-878-1441*

VISA

NUTS & VOLTS MAGAZINE

P.O. Box 1111-H
PLACENTIA, CA 92670
714-632-7721

9th YEAR

Ham Radio
Computer Hardware
Computer Software
Plans-Kits
Schematics
Test Equipment
CB Gear
Satellite TV
Video
Components
Antique Electronics
Cable TV
Publications
Repairs-Services
New Products
Events Calender

IF YOU ARE INTO ELECTRONICS AND SAVING MONEY IS IMPORTANT TO YOU, THEN YOU OWE IT TO YOURSELF TO TRY NUTS & VOLTS MAGAZINE. DISCOVER WHY THOUSANDS OF SMART PEOPLE NATIONWIDE TURN TO NUTS & VOLTS EACH MONTH TO MEET THEIR ELECTRONIC NEEDS. WHETHER YOU'RE BUYING, SELLING, OR JUST TRYING TO LOCATE THOSE UNIQUE OR HARD-TO-FIND ITEMS, FIND OUT HOW NUTS & VOLTS CAN HELP!

SUBSCRIBE TODAY!

☐ CHECK ☐ MONEY ORDER ☐ VISA ☐ MC

Name _____
Address _____
City _____
State _____ Zip _____
Card No. _____ Exp. Date _____

CALL FOR ADVERTISING INFORMATION
DISTRIBUTOR INQUIRIES INVITED

Subscription Rates
U.S. FUNDS REQUIRED

3rd Class Mail - USA
One Year $12.00
Two Years $21.00
Lifetime $60.00

1st Class Mail
One Year - USA . . . $20.00
Canada & Mexico . . $22.00

Air Mail
Foreign - 1 Year . . . $55.00

Includes one FREE 40-word Classified Ad

A National Publication For The Buying And Selling Of Electronic Equipment

181



ELMER's NOTEBOOK

Tom McMullen, W1SL

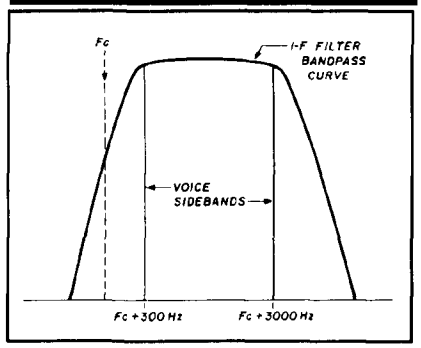
SSB basics — receiving the signal

This is the second half of a discussion of SSB begun in November. Last month I explained how SSB was generated and translated (heterodyned) to the Amateur bands, and touched on some benefits of using that mode of communication. This month, I'll look at how SSB is received and talk about the peculiarities of the mode that make receiver design a bit tricky.

The first part of a receiver that SSB signals encounter after being picked up by the antenna is the front end, or RF amplifier stage(s). There are no unusual features making the front end for SSB any different from that for any other mode. The usual criteria apply — low noise, freedom from overload by strong signals, and enough selectivity to reject out-of-band signals.

The next stage encountered is an i-f amplifier. Some receivers have two intermediate frequencies with an extra conversion to get from one to the other; others have only one conversion to a single i-f. Common frequencies are 10.7, 9.0, and 5.5 MHz, but others can work as well. In either case, a local oscillator is mixed with the incoming SSB signal to produce the i-f. This is done in a heterodyning system, just as it was at the transmitting end to get the generated sidebands on the ham band of interest. In the example given last month, a 19.5-MHz signal was mixed with 9.0-MHz SSB to produce output on 28.5 MHz. The same process works in reverse — mixing 28.5-MHz SSB with a local oscillator of 19.5 MHz produces an i-f at 9.0 MHz. These 9-MHz sidebands are pretty much carbon copies of the ones generated by the balanced modulator and then filtered before being amplified and transmitted. In fact, many of today's popular transceivers use the very same filters for the i-f in receiving a signal as they do for generating the sidebands in a transmitter. The filter is switched between the receiving and transmitting circuitry by means of diodes and/or transistors, and thus made to serve double duty. The resulting output from this filter is a range of voice "sidebands" that covers approximately 300 to 3000 Hz, just as in the transmitter. (See **fig. 1**.)

FIGURE 1



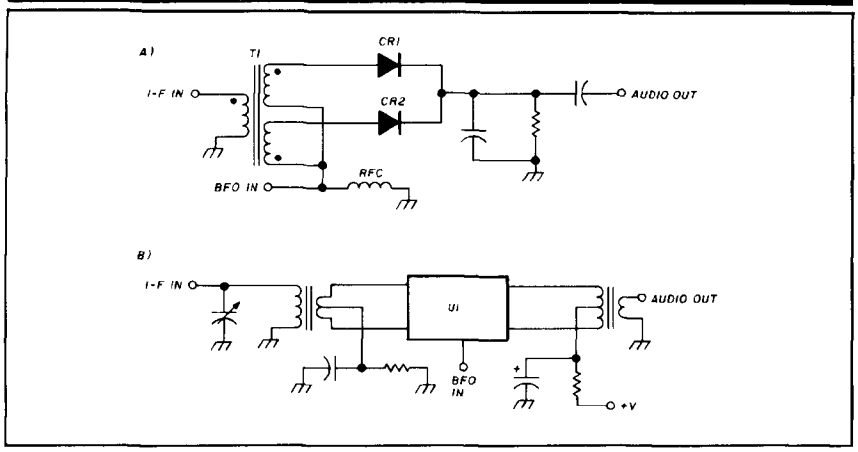
A single-sideband signal as it appears in the receiver i-f stages is a band of audio frequencies covering approximately 300 to 3000 Hz. This signal should be practically identical to the one generated by the balanced modulator and filter combination discussed in last month's column.

Putting the carrier back

At this point, a common diode detector like that used for AM signals wouldn't be able to translate these sidebands into anything useful. The next step is to add an RF carrier in exactly the same relationship as the one that was suppressed in the transmitter. This isn't hard to do. All it takes is an oscillator at the right frequency and a mixer to combine the sidebands with the signal from that oscillator. You'll then have an AM carrier with one sideband, which an ordinary diode detector can turn into audio. Some early attempts at receiving SSB with the AM/CW receivers of the day showed how poor an idea this is.

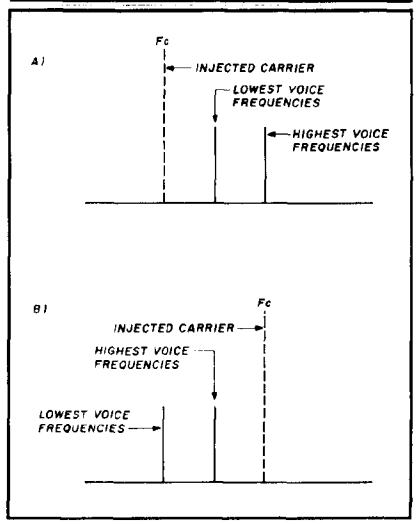
In the early days of SSB, the receiver's beat-frequency oscillator (BFO) used for CW reception was pressed into service to supply the missing carrier, and the AM detector took over from there. The trick was to tune in the sidebands for maximum loudness (even if you couldn't understand the voice), then move the BFO around until you heard something you could understand. Hopefully, you could get a somewhat normal-sounding voice

FIGURE 2



Simplified versions of two product detector circuits. Diodes, as at A, involve the least number of components and offer great simplicity. The dots on T1 indicate wiring polarity. An integrated circuit at B can provide gain and increased sensitivity. Bias and decoupling components for U1 are not shown.

FIGURE 3



Placing the local carrier on the wrong side of the SSB signal can produce unintelligible audio. At A, the carrier is correctly placed below the upper sideband signal and the audio is "right-side-up." If the carrier is placed on the other side, as at B, the audio is inverted; i.e., the higher voice frequencies are near the carrier and the lower ones are farther from it. The resulting inverted voice frequencies are unreadable.

out of this. The poor quality, frequency drift, and constant "tweaking" to keep the signal tuned in, turned many hams away from this "new mode".

Better circuits were not long in coming, and their improvements led to today's increased efficiency and better quality SSB. One of these circuits is called the "product detector." This type of circuit produces an output only when both inputs are present; that is, the BFO must be on and the SSB signal must be present before the detector provides an audio signal output. Diagrams of two types of product detector are shown in **fig. 2**.

There are many versions of product detectors and most work quite well. Some equipment manufacturers are going for the simplicity of the diode circuit; others are using integrated circuit types, often combining the detector function with an audio preamplifier or some other part of the receiver circuit. Another type of detector circuit uses JFETS or MOSFETS as the active element.

Sounds good but...

Sometimes you get funny "audio" when you tune in an SSB signal. To understand how this happens, let's look at **fig. 3**. In **3A**, the carrier is placed in its correct relationship to the sidebands. In this example, the signal is upper sideband so the carrier is below, and the lower voice frequencies are closest to the carrier. The higher frequencies are farther from the carrier, just as they were when the original sidebands were generated.

Switch the carrier to the other side of the sidebands, as in **fig. 3B** and watch what happens. The higher voice frequencies are now close to the carrier, while the low frequencies are farther away. The result is an "inverted" voice that's impossible to understand. The range of speech frequencies has been inverted.

This "inversion" is something that receiver designers have to watch for when they heterodyne signals from the various Amateur bands down to an i-f, or mix generated SSB with a local oscillator to get to an Amateur band. For instance, look at my earlier example of mixing 28.5 MHz with 19.5 MHz to obtain 9-Mhz i-f output. You can also get a 9-MHz difference (i-f) by mixing 28.5 MHz with 37.5 MHz, but the signal will be inverted compared to that obtained with 19.5 MHz. The 9.0-MHz sidebands in your detector will sound just as scrambled as if you tuned them in wrong, or selected the wrong position of your upper/lower sideband switch. You can correct this inversion by selecting the other sideband to "uninvert" the audio. In some receivers and transceivers, just such a scheme is used in order to use simplified circuitry for local oscillators. A 9.0-MHz SSB signal mixed with 5.0 MHz produces 4.0 MHz for 75-meter work (9.0 − 5.0 = 4.0), and can also produce 14.0 MHz for 20 meters (9.0 + 5.0 = 14.0). The sidebands will be inverted for one band, so the correct BFO crystal for generating (or receiving) the signal must be used as required to produce audio that is "right-side-up." Some early receivers had colored dial and knob markings as a reminder to switch to upper or lower sideband to match the Amateur band you were listening to. Incidently, in the frequency-mixing example just used, the sidebands are not the only inversion — look what happens if you make the 5.0-MHz oscillator signal variable (VFO) to tune across the band. In the 75-meter case, if you increase the VFO frequency to 5.1 MHz, subtracting that

from 9.0 shows that you are now tuned to 3.9 MHz. So to tune "down" the band, you *increase* the frequency of the VFO. For 20 meters, the opposite is true — 5.1 + 9.0 = 14.1 MHz. This is a case where you must keep your pluses and minuses straight!

Happily, improved circuit design and manufacturing techniques make it easy to build oscillators and mixer circuitry that is tailored to each band. Now it's no great chore to avoid this inversion problem in modern transceiver design, unless you are striving for the minimum number of parts.

Other modes

An additional benefit of modern improved circuitry for receiving SSB is better reception of CW. The product detector, with its lower noise, helps in weak signal reception. The improved oscillator stability needed for constant voice quality also helps the CW signal stay put on the dial. The SSB filters used in the receiver i-f work okay for CW reception, but most people who use code a lot prefer an additional set of filters that narrow the "window" to only that necessary to receive a few hundred hertz of spectrum. Why listen to more signals than you absolutely have to?

The product detector also works for AM reception; just turn off the local BFO and let the original carrier ride through. The narrow filter for SSB will restrict AM quality somewhat, but it's still adequate. Wider filters are available that can be switched into the i-f system for AM use if better audio quality is desired.

I'd like to thank those of you who have taken the time to write to me about what you've seen in this column, and on many other interesting subjects. I can't answer each letter personally, but each is carefully read. Your thoughts and comments are appreciated. The article about "Q" signals generated several interesting letters (as did the mention of "Z" signals in that article). Some letters provided me with new information. Again, many thanks to each of you.

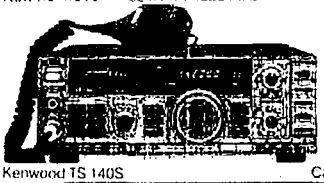
Article L **HAM RADIO**

MADISON SHOPPER

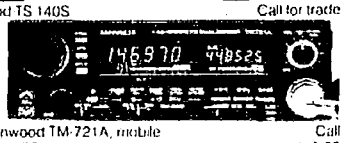
CALL FOR ORDERS
1 (800) 231-3057
1-713-520-7300 OR 1-713-520-0550
TEXAS ORDERS CALL COLLECT
FAX 1-713-771-7759

ALL ITEMS ARE GUARANTEED OR SALES PRICE REFUNDED

New Icom IC 781 — Trades wanted
Kenwood TH215A, TH25AT — Trade in your old HT
New Kenwood TM-621A, 144/220 MHz FM — Call



Kenwood TS 140S — Call for trade



New Kenwood TM-721A, mobile — Call
ICOM 28H/1TM — 410.00



IC 781	Call
Icom 761	2300.00
Shure 444D	56.95
HEIL BM10 Boom Mike, wired 8 pin	69.00
HEIL HM5 Desk Mike	62.00
NYE MB5A Tuner	569.00
Alpha Delta Transtrap HV	33.00
CSI Private Patch IV	469.00
Ameco PT-3 Pre Amp	99.00
Larsen 2-meter on glass	49.95
Anteco 2M 5/8 Mag Mount Comp	25.00
Van Gordon G5RV	44.00
Valor AB5 mobile	79.00
Thousands of panel meters	3.95 up CALL
Aerovox 1000 pf/500 V feedthrough caps	1.95
Transformer 120 V Pri 1050 V/1A (Sec #18 Wire)	50.00
100 mfd/450V Axial Cap	2.20
120 mfd/450V Axial Cap	3.00
Ansta SWR Bridge 3-30 MHz	19.95
83-1SP-PL259 Silverplate (Amphenol)	1.50
82-61-N Male (Amphenol)	3.50
82-202-1006 N Male (9913)	3.50
Double Female UHF	1.00
UG176 RG8X	each .40
Receiving tubes 50-90% off list price	Call
Santec Boom Mike/Headset (fits ICOM)	20.00
Rohn SA 25G 67 (67 inside arm)	each 125.00

USED EQUIPMENT
All equipment used, clean, with 90 day warranty and 30 day trial. Six months full trade against new equipment. Sale price refunded if not satisfied.
Call for latest used gear
(800) 231-3057

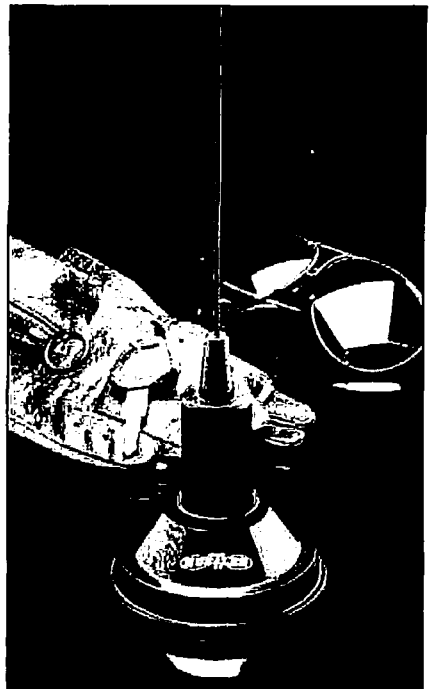
Don's Corner:
Have you tried the new Delta Loop Antenna?
I have and it works great!
Contact: Delta Loop Antenna
P.O. Box 8063
New Fairfield, CT 06812
See CQ June '88 Review

GNU PROD
TE Systems 2m Amp: 30-160 watts GaAs fet — $229.00

POLICIES
Minimum order $10.00. Mastercard, VISA, or C.O.D. All prices FOB Houston, except as noted. Prices subject to change without notice. Items subject to prior sale. Call anytime to check the status of your order. Texas residents add sales tax. All items full factory warranty plus Madison warranty.
Bird and Bolden products in stock. Call today.

MADISON
Electronics Supply
3621 FANNIN
HOUSTON, TEXAS 77004
MasterCard VISA

✓ 196



Drive A Winner

The performance of your system depends upon the antenna it drives.

Drive A Winner – Hustler.

✓ Yes, please send information on your line of amateur antennas to:

NAME _____

ADDRESS _____

CITY STATE ZIP

HUSTLER

One Newtronics Place
Mineral Wells, Texas 76067
(817) 325-1386

✓ 197

NEW products

(continued from page 104)

AVCOM's agile SCPC demodulator

AVCOM introduces a Single Channel Per Carrier Demodulator, the SCPC-3000E.

The SCPC-3000E Demodulator features a high-performance synthesized 50-90 MHz tuning module. Frequencies are tunable in 800 steps of 50 kHz each. Standard expansions are 3:1 and 2:1, with other expansion formats available. Deemphasis is switchable between 0, 25, 50, and 75 microseconds. Selectable low-pass 15, 7.5, and 5-kHz audio filters are also standard. Wideband and narrowband versions are available.

The price of the SCPC-3000E is $1378; the SCPC-3000E is rack-mountable and available for immediate delivery.

For more details contact AVCOM, 500 Southlake Boulevard, Richmond, Virginia 23236.

Circle #310 on Reader Service Card.

Clamp-on multimeter accessory measures DC and AC current

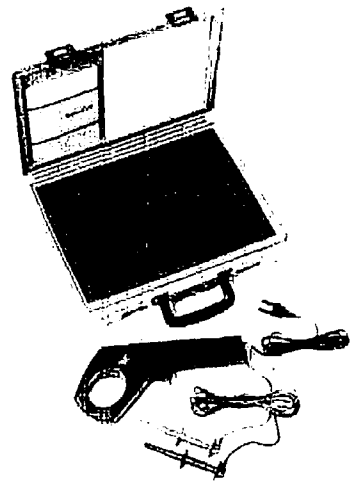
The new 80i-kW Current/Power Probe, from John Fluke Co., Inc., is a clamp-on multimeter accessory for measuring DC or AC current, and AC power in kilowatts. The probe accepts conductors of up to 2-1/4 inches in diameter.

Measurement range of the 80i-kW is 1A to 1300A DC, 1A to 1000A AC, and 0.5 kW to 330 kW. The switch-selectable output signal is 1mV per amp or 1mV per kW. The power factor can also be calculated from data measured by the 80i-kW.

The probe comes with voltage test leads that have safety alligator clips. Designed specifically for the 80i-kW, these test leads provide a voltage input that, in conjunction with the current input, give a readout in kilowatts on the multimeter.

The 80i-kW comes with a carrying case with space for accessories. An instruction booklet, a battery, and quick reference guide are included in the case, which can also hold any Fluke handheld multimeter, a Fluke 80TK thermocouple module, or one or more of the Fluke 80PK Series temperature probes.

The 80i-kW is available for immediate delivery at a U.S. list price of $395 from over 600 distributor locations in the United States, or through Fluke's worldwide sales network.



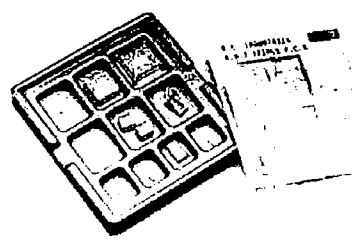
For more information on the Fluke 80i-kW Current/Power Probe, in North America and non-European countries write to John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206 or call toll free 800-443-5853, ext. 77. In Europe, contact Philips Test and Measurement, Building HFK, 5600 MD Eindhoven, The Netherlands.

Circle #311 on Reader Service Card.

New SMT trials kit

OK Industries has introduced the SMT-K1, a kit that enables those who work with surface mounted devices to evaluate, practice, or train on assembly, production, or rework techniques.

The kit includes a full range of surface-mounted components including chip capacitors, transistors, PLCCs, and 100-pin gull-wing flat packs. The SMT-K1 also contains a trial board designed to accomodate a wide variety of components. The board and components come complete in a reusable conductive tray.



The list price for the SMT-K1 is $64.95.

For further information contact OK Industries, 4 Executive Plaza, Yonkers, New York 10701.

Circle #312 on Reader Service Card.

New series of Kelvin Probes

O.K. Industries Inc. Electronics Division introduces a new series of Kelvin Probes. The TK800 Series probes are very low resistance, precision test lead kits ideal for LCR bridges or microhm meters.

Circuit connection: (2) flat tweezers with special gripping surfaces ensure precise contact to the components to be measured. Contacts are gold plated for optimum electrical performance. An additional alligator clip, ground lead connection is also provided.

Instrument connection: (4) BNC or banana connectors with color-coded strain-relief boots. Specifications: 250V rms, 5A current with 0.8M cable length.

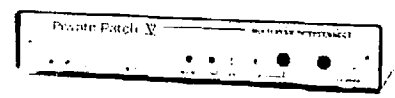
The TK800 series is Ex-stock. The list price is $119.00.

For details contact OK Industries, 4 Executive Plaza, Yonkers, New York 10701, 1-800-523-0667.

Circle #312 on Reader Service Card.

Multi-mode autopatch and repeater controller

Connect System Inc.'s new Private Patch V can be user programmed into four selectable operating modes: Sampling Patch (vox enhanced), Vox Patch (can operate through remotely located repeaters), Duplex Patch, and Repeater Controller with Duplex Patch (perfect for club systems).



Private Patch V has a built-in keyboard and digital display that gives you complete control of all features and operating modes. Features include: a ninety number auto-dialer, last number redial, remote hook-flash, keyboard programmable CW ID, toll protection, 1-5 digit access code, 2-5 digit secret toll override code, telephone remote base, remote controlled relay, and regenerated tone/pulse dialing.

A plug-in CTCSS board that converts all modes to CTCSS operation (32 selectable tones) and an Electronic Voice Delay board which enhances performance in vox mode are optional.

For more information, contact: Connect Systems Inc. 23731 Madison Street, Torrence, California 90505.

Circle #313 on Reader Service Card.